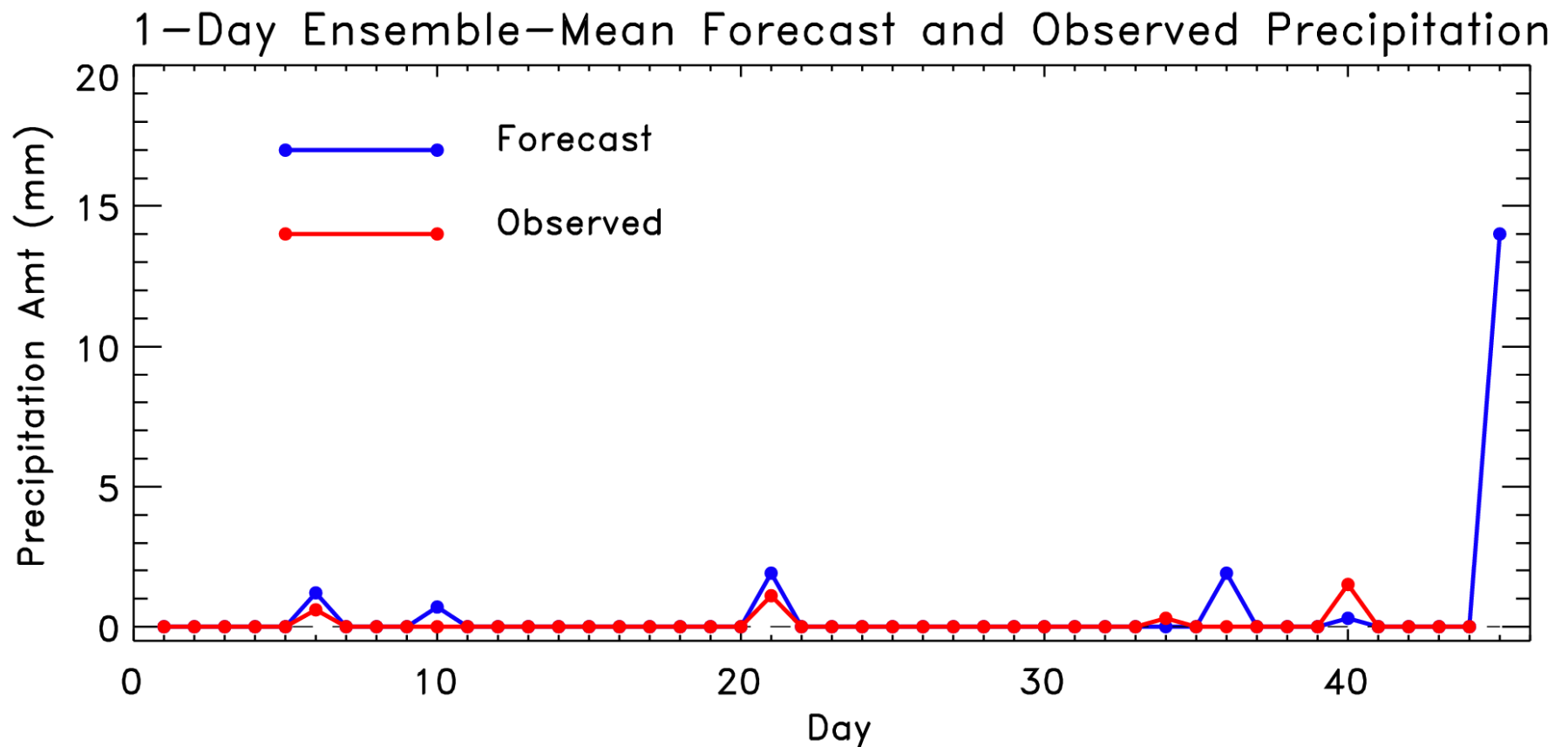


Experimental statistically post-processed guidance based on the NCEP GEFS reforecasts.

Tom Hamill and Gary Bates
NOAA ESRL, Physical Sciences Division
tom.hamill@noaa.gov

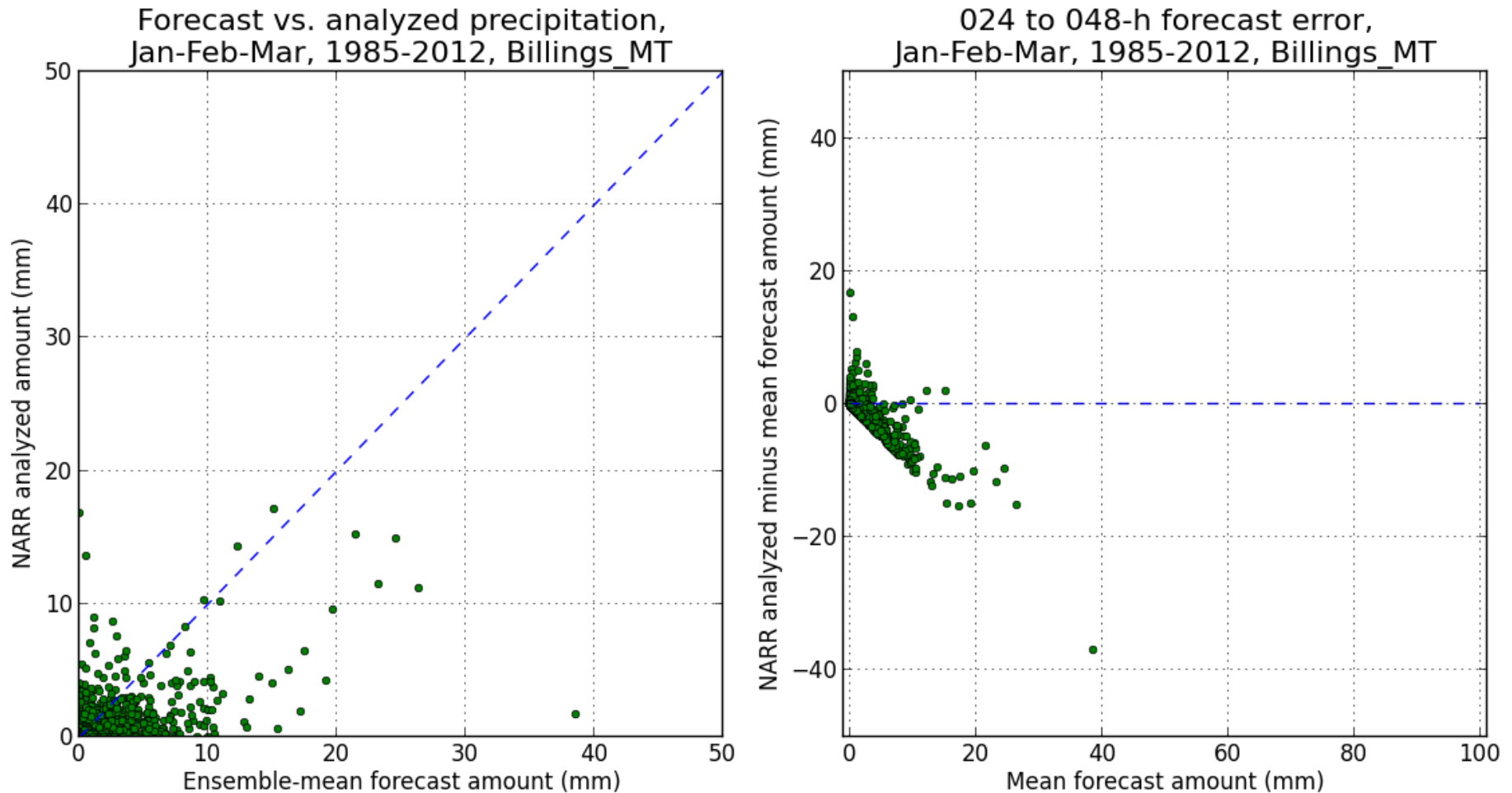
also: Jeff Whitaker, Don Murray, Francisco Alvarez, Mike Fiorino, Tom Galarneau

Reminder: statistical post-processing for rare events is challenging without a large training sample



Say you want to statistically post-process today's model precipitation forecast to improve it. Heavy precipitation events like the one today are the ones you care about the most. How do you calibrate today's forecast given past short sample of forecasts and observations?

Example of forecast / analysis data



Assuming forecast errors may be location dependent, it's helpful to have a lot of samples in order to post-process these rare events.

Reforecasts (hindcasts)

- Numerical simulations of the past weather (or climate) using the same forecast model and assimilation system that (ideally) is used operationally.
 - Common with climate, uncommon with weather models.

2nd-generation GEFS reforecast: details

- Seeks to mimic GEFS operational configuration as of February 2012. This version still operational, though data assimilation method was improved in May 2012.
- Reforecasts produced **every day, for 1984120100 to current.**
- **Each 00Z, 11-member forecast**, 1 control + 10 perturbed.
- CFSR (NCEP's Climate Forecast System Reanalysis) initial conditions (3D-Var) + ETR perturbations (cycled with 10 perturbed members). After ~ 22 May 2012, initial conditions from hybrid EnKF/3D-Var.
- Resolution: T254L42 to day 8, T190L42 from days 7.5 to day 16.
- Fast data archive at ESRL of 99 variables, 28 of which stored at original ~1/2-degree resolution during week 1. All stored at 1 degree. Also: mean and spread to be stored.
- Full archive at DOE/Lawrence Berkeley Lab, where data set was created under DOE grant.

Status of the reforecast v2 archive.

- 00Z reforecast data and (since mid-2012) 00Z GEFS real-time forecasts are publicly available from our archive.
- Download web sites are open to you now:
 - NOAA/ESRL site: fast access, limited data (99 fields). Also there, README & info on how to ftp.
 - <http://www.esrl.noaa.gov/psd/forecasts/reforecast2/>
 - US Department of Energy: slow access, but full model states. Recent months not uploaded yet.
 - <http://portal.nersc.gov/project/refcst/v2/>

Data that is readily available from ESRL

Table 1: Reforecast variables available for selected mandatory and other vertical levels. Φ indicates geopotential height, and an X indicates that this variable is available from the reforecast data set at 1-degree resolution; a Y indicates that the variable is available at the native ~ 0.5 degree resolution. AGL indicates “above ground level.”

Vertical Level	U	V	T	Φ	q	Wind Power
10 hPa	X	X	X	X		
50 hPa	X	X	X	X		
100 hPa	X	X	X	X		
200 hPa	X	X	X	X		
250 hPa	X	X	X	X		
300 hPa	X	X	X	X	X	
500 hPa	X	X	X	X	X	
700 hPa	X	X	X	X	X	
850 hPa	X	X	X	X	X	
925 hPa	X	X	X	X	X	
1000 hPa	X	X	X	X	X	
$\sigma \approx 0.996$	X	X		X		
$\sigma \approx 0.987$	X	X		X		
$\sigma \approx 0.977$	X	X		X		
$\sigma \approx 0.965$	X	X		X		
80m AGL	X,Y	X,Y				X,Y

Also: hurricane track files and other hurricane diagnostic information

Data that is readily available from ESRL

Variable (units)
Mean sea-level pressure (Pa) [Y]
Skin temperature (K) [Y]
Soil temperature, 0.0 to 0.1 m depth (K) [Y]
Volumetric soil moisture content 0.0 to 0.1 m depth (fraction between wilting and saturation) [Y]
Water equivalent of accumulated snow depth (kg m^{-2} , i.e., mm) [Y]
2-meter temperature (K) [Y]
2-meter specific humidity (kg kg^{-1} dry air) [Y]
Maximum temperature (K) in last 6-h period (00, 06, 12, 18 UTC) or in last 3-h period (03, 09, 15, 21 UTC) [Y]
Minimum temperature (K) in last 6-h period (00, 06, 12, 18 UTC) or in last 3-h period (03, 09, 15, 21 UTC) [Y]
10-m u wind component (ms^{-1}) [Y]
10-m v wind component (ms^{-1}) [Y]
Total precipitation (kg m^{-2} , i.e., mm) in last 6-h period (00, 06, 12, 18 UTC) or in last 3-h period (03, 09, 15, 21 UTC) [Y]
Water runoff (kg m^{-2} , i.e., mm) [Y]
Average surface latent heat net flux (W m^{-2}) [Y]
Average sensible heat net flux (W m^{-2}) [Y]
Average ground heat net flux (W m^{-2}) [Y]
Convective available potential energy (J kg^{-1}) [Y]

Convective inhibition (J kg^{-1}) [Y]
Precipitable water (kg m^{-2} , i.e., mm) [Y]
Total-column integrated condensate (kg m^{-2} , i.e., mm) [Y]
Total cloud cover (%)
Downward short-wave radiation flux at the surface (W m^{-2}) [Y]
Downward long-wave radiation flux at the surface (W m^{-2}) [Y]
Upward short-wave radiation flux at the surface (W m^{-2}) [Y]
Upward long-wave radiation flux at the surface (W m^{-2}) [Y]
Upward long-wave radiation flux at the top of the atmosphere (W m^{-2}) [Y]
Potential vorticity on the 320K isentropic surface ($\times 10^{-6} \text{ K m}^2 \text{ kg}^{-1} \text{ s}^{-1}$)
U component on 2 PVU (1 PVU = $1 \times 10^{-6} \text{ K m}^2 \text{ kg}^{-1} \text{ s}^{-1}$) isentropic surface (ms^{-1})
V component on 2 PVU isentropic surface (ms^{-1})
Temperature on 2 PVU isentropic surface (K)
Pressure on 2 PVU isentropic surface (Pa)
80-m u wind component (ms^{-1}) [Y]
80-m v wind component (ms^{-1}) [Y]
Vertical velocity at 850 hPa (Pa s^{-1})
Water runoff (kg m^{-2} , i.e., mm)
Wind mixing energy at 80 m (J) [Y]

[Y] indicates that this variable is available at the native ~0.5-degree resolution as well as the 1-degree resolution. 8

<http://esrl.noaa.gov/psd/forecasts/reforecast2/download.html>

Select Desired Variables and Associated Levels:

Single Level (1°x1°) Pressure Levels (1°x1°) Hybrid Levels (1°x1°) Single Level (Gaussian ~.5°)

<input type="radio"/> Total Accumulated Precipitation	<input type="radio"/> Temperature at 2 meters
<input type="radio"/> U-Component of Wind at 10 meters	<input type="radio"/> V-Component of Wind at 10 meters
<input type="radio"/> U-Component of Wind at 80 meters	<input type="radio"/> V-Component of Wind at 80 meters
<input type="radio"/> Convective Available Potential Energy	<input type="radio"/> Convective Inhibition
<input type="radio"/> Surface Downward Long-Wave Radiation Flux	<input type="radio"/> Surface Downward Short-Wave Radiation Flux
<input type="radio"/> Surface Upward Long-Wave Radiation Flux	<input type="radio"/> Surface Upward Short-Wave Radiation Flux
<input type="radio"/> Ground Heat Flux	<input type="radio"/> Surface Latent Heat Net Flux
<input type="radio"/> Surface Sensible Heat Net Flux	<input type="radio"/> Mean Sea Level Pressure
<input type="radio"/> Surface Pressure	<input type="radio"/> Precipitable Water
<input type="radio"/> Volumetric Soil Moisture Content	<input type="radio"/> Specific Humidity at 2 meters
<input type="radio"/> Total Cloud Cover	<input type="radio"/> Total Column-Integrated Condensate
<input type="radio"/> Skin Temperature	<input type="radio"/> Maximum Temperature
<input type="radio"/> Minimum Temperature	<input type="radio"/> Soil Temperature (0-10 cm below surface)
<input type="radio"/> Upward Long-Wave Radiation Flux	<input type="radio"/> Water Runoff
<input type="radio"/> Water Equivalent of Accumulated Snow Depth	<input type="radio"/> Wind Mixing Energy
<input type="radio"/> Vertical Velocity at 850 hPa Surface	<input type="radio"/> Temperature on 2 PVU Surface
<input type="radio"/> Pressure on 2 PVU Surface	<input type="radio"/> U-Component of Wind on 2 PVU Surface
<input type="radio"/> V-Component of Wind on 2 PVU Surface	<input type="radio"/> Potential Vorticity on 320 K Isentrope

Produces
netCDF files.

Also: direct
ftp access to
allow you to
download the
raw grib files.

Select Desired Dates (Available from Dec 1 1984 to Dec 31 2010):

From: To:

- ☒ Download all the forecasts within the chosen time period. [Help](#)
☐ Download forecasts within the month-days range for the chosen years. [Help](#)

Select Desired Forecast Hour(s):

High Resolution: (Select All or Clear)

- | | | | | | | | | | |
|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| <input type="checkbox"/> 0 | <input type="checkbox"/> 3 | <input type="checkbox"/> 6 | <input type="checkbox"/> 9 | <input type="checkbox"/> 12 | <input type="checkbox"/> 15 | <input type="checkbox"/> 18 | <input type="checkbox"/> 21 | <input type="checkbox"/> 24 | <input type="checkbox"/> 27 |
| <input type="checkbox"/> 30 | <input type="checkbox"/> 33 | <input type="checkbox"/> 36 | <input type="checkbox"/> 39 | <input type="checkbox"/> 42 | <input type="checkbox"/> 45 | <input type="checkbox"/> 48 | <input type="checkbox"/> 51 | <input type="checkbox"/> 54 | <input type="checkbox"/> 57 |
| <input type="checkbox"/> 60 | <input type="checkbox"/> 63 | <input type="checkbox"/> 66 | <input type="checkbox"/> 69 | <input type="checkbox"/> 72 | <input type="checkbox"/> 78 | <input type="checkbox"/> 84 | <input type="checkbox"/> 90 | <input type="checkbox"/> 96 | <input type="checkbox"/> 102 |
| <input type="checkbox"/> 108 | <input type="checkbox"/> 114 | <input type="checkbox"/> 120 | <input type="checkbox"/> 126 | <input type="checkbox"/> 132 | <input type="checkbox"/> 138 | <input type="checkbox"/> 144 | <input type="checkbox"/> 150 | <input type="checkbox"/> 156 | <input type="checkbox"/> 162 |
| <input type="checkbox"/> 168 | <input type="checkbox"/> 174 | <input type="checkbox"/> 180 | <input type="checkbox"/> 186 | <input type="checkbox"/> 192 | | | | | |

Low Resolution: (Select All or Clear)

- | | | | | | | | | | |
|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| <input type="checkbox"/> 186 | <input type="checkbox"/> 192 | <input type="checkbox"/> 198 | <input type="checkbox"/> 204 | <input type="checkbox"/> 210 | <input type="checkbox"/> 216 | <input type="checkbox"/> 222 | <input type="checkbox"/> 228 | <input type="checkbox"/> 234 | <input type="checkbox"/> 240 |
| <input type="checkbox"/> 246 | <input type="checkbox"/> 252 | <input type="checkbox"/> 258 | <input type="checkbox"/> 264 | <input type="checkbox"/> 270 | <input type="checkbox"/> 276 | <input type="checkbox"/> 282 | <input type="checkbox"/> 288 | <input type="checkbox"/> 294 | <input type="checkbox"/> 300 |
| <input type="checkbox"/> 306 | <input type="checkbox"/> 312 | <input type="checkbox"/> 318 | <input type="checkbox"/> 324 | <input type="checkbox"/> 330 | <input type="checkbox"/> 336 | <input type="checkbox"/> 342 | <input type="checkbox"/> 348 | <input type="checkbox"/> 354 | <input type="checkbox"/> 360 |
| <input type="checkbox"/> 366 | <input type="checkbox"/> 372 | <input type="checkbox"/> 378 | <input type="checkbox"/> 384 | | | | | | |

portal.nersc.gov/project/refcst/v2/

Bookmarks 25 Calendar ESRL Library NOAA Directory NCARPeople HFIP Global Forecasts TinyURL Comcast Matplotlib: Axes

Web Gateway for Global Ensemble Reforecast Data, Version 2

This web page allows users to download selected days of the full model output from the 2nd-generation NOAA Global Ensemble Forecast System Reforecast (GEFS/R). The format of data downloaded from this page is "grib2" format. It is incumbent on the user to be familiar with the use of this data format as we can provide only minimal user support. For more information on grib2 data, please see [GRIB2 use at NCEP](#).

This reforecast mimics the operational ensemble system that the National Weather Service put into operations in February 2012. The control forecast initial conditions were generated from the [Climate Forecast System Reanalysis \(CFSR\)](#). 10 perturbed initial conditions were generated using the ensemble transform with rescaling (ETR; Wei et al. 2008). Model uncertainty was simulated following Hou et al 2008. Forecasts out to 16 days were generated from 00 UTC initial conditions every day from December 1984 through 2010.

We anticipate that these full model fields provided here will be useful, for example, in providing initial and/or lateral boundary conditions for regional reforecasts with various limited-area models. To access a subset of model output, for example a small number particular fields such as precipitation, surface temperatures, etc., please use the interface at [ESRL/PSD](#). For a more complete description of this reforecast data set, please read [\[insert URL\]](#).

Please submit only one request at a time. If you encounter problems downloading data, please contact esrl.psd.reforecast2@noaa.gov

This 2nd-generation GEFS/R was generated under a DOE supercomputer grant at Lawrence Berkeley Lab.

Select Desired Date (from Dec. 1, 1984 to Dec. 31, 2010):

Date

Select Ensemble Members:

Control: ☐ Perturbation: ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

1 2 3 4 5 6 7 8 9 10

[Select All](#) or [Clear](#)

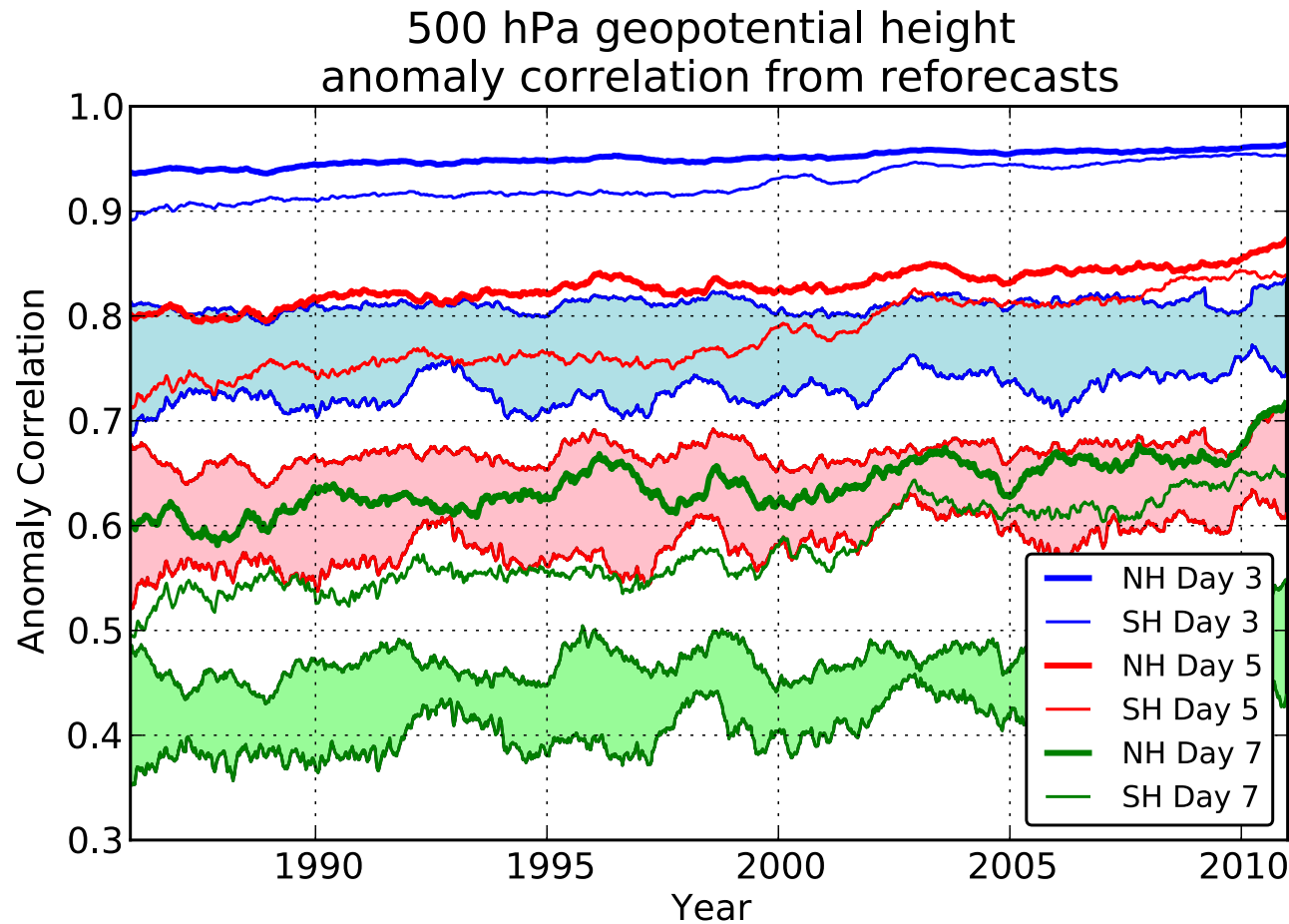
Email Address to Notify When File is Ready:

This DOE site permits access to tape storage of full data (slower).

Use this to access full model state, e.g., to initialize and provide lateral boundary conditions to run WRF on an old case.

Skill of the raw reforecasts (no post-processing)

500 hPa Z anomaly correlation (from deterministic control)

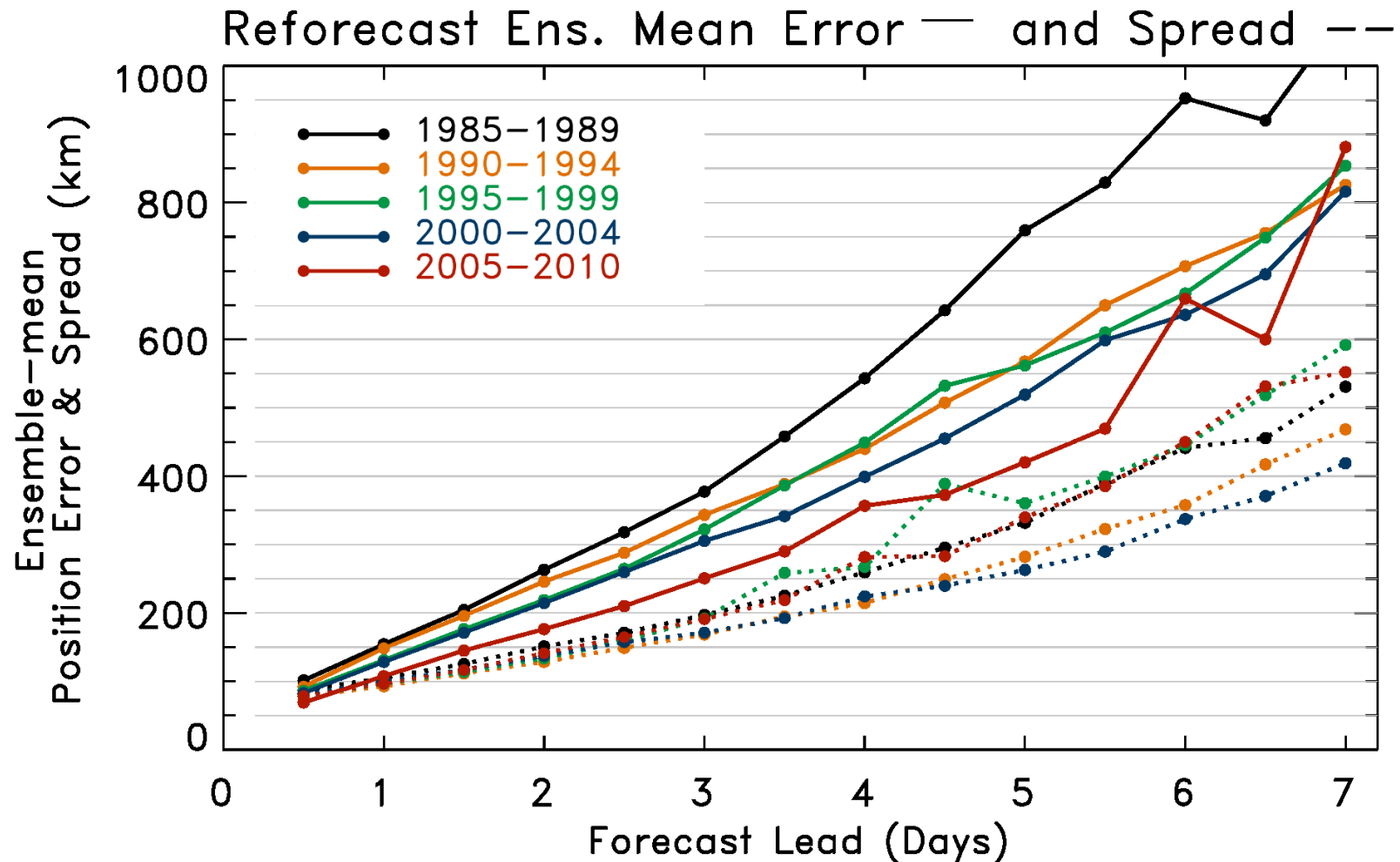


Lines w/o filled colors
for second-generation
reforecast (2012, T254)

Lines with filled colors
for first-generation
reforecast (1998, T62).

Perhaps a 1.5-2.5 day
improvement.

Tropical cyclone track errors



Less statistical consistency of errors over the period of the reforecasts, as opposed to 500 hPa anomaly correlation, which emphasizes mid-latitude variability.

Madden-Julian Oscillation (MJO) deterministic verification metrics

$$\text{COR}(\tau) = \frac{\sum_{i=1}^N [a_{1i}(t)b_{1i}(t) + a_{2i}(t)b_{2i}(t)]}{\sqrt{\sum_{i=1}^N [a_{1i}^2(t) + a_{2i}^2(t)]} \sqrt{\sum_{i=1}^N [b_{1i}^2(t) + b_{2i}^2(t)]}},$$

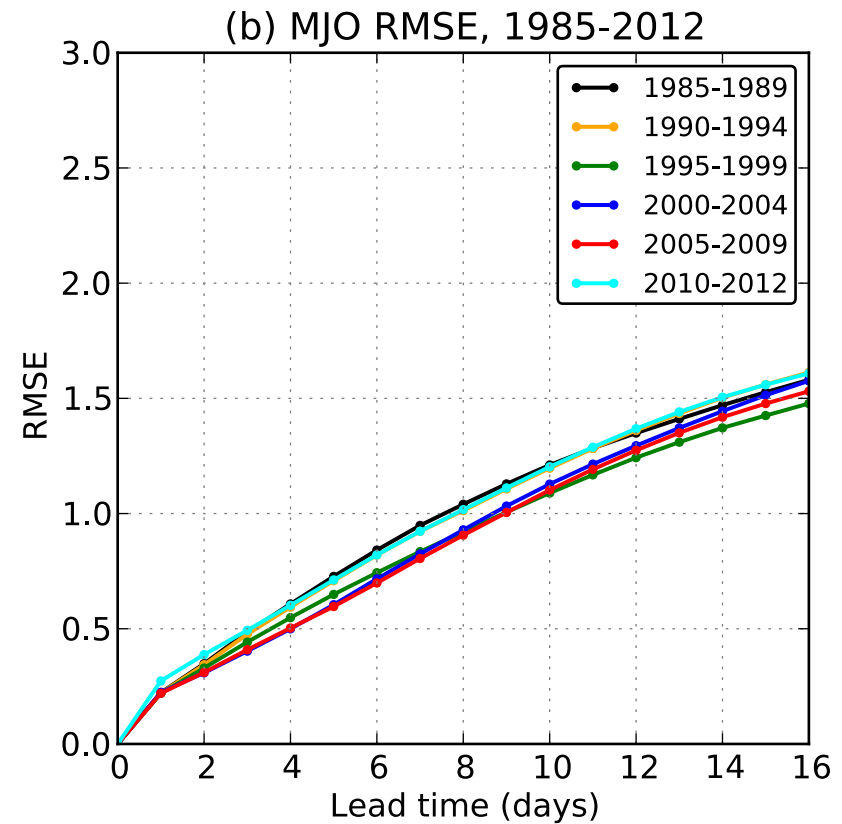
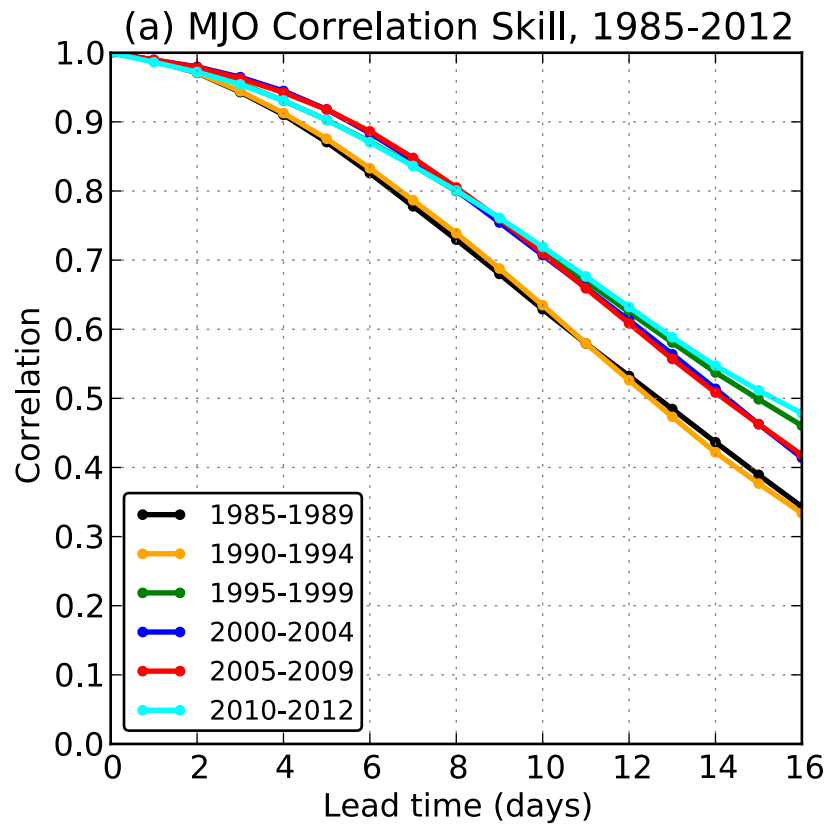
where $a_{1i}(t)$ and $a_{2i}(t)$ are the observed RMM1 and RMM2 at day t , and $b_{1i}(t)$ and $b_{2i}(t)$ are their respective forecasts, for the i th forecast with a τ -day lead. Here, N is the number of forecasts.

$\text{COR}(\tau)$ measures the skill in forecasting the phase of the MJO, which is insensitive to amplitude errors. $\text{COR}(\tau)$ is equivalent to a spatial pattern correlation between the observations and the forecasts when they are expressed by the two leading combined EOFs.

$$\text{RMSE}(\tau) = \sqrt{\frac{1}{N} \sum_{i=1}^N \{[a_{1i}(t) - b_{1i}(t)]^2 + [a_{2i}(t) - b_{2i}(t)]^2\}}.$$

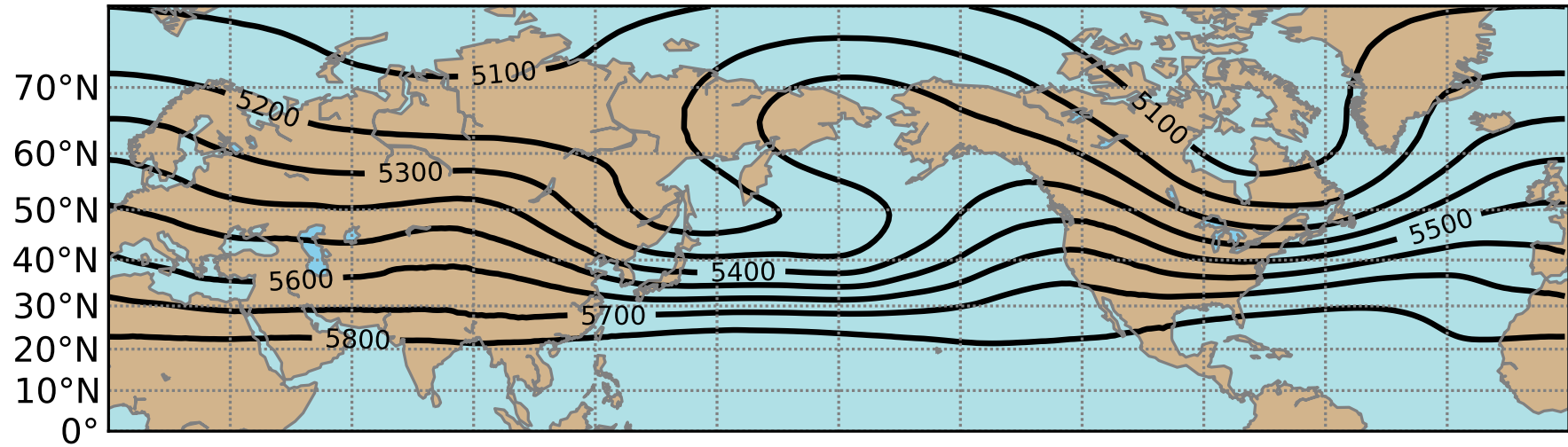
RMM1 ($= a_1$) and RMM2 ($= a_2$) measure the projection onto the first two principal components of MJO variability.

MJO: Bi-variate RMM1 and RMM2 correlation and RMSE by half decade

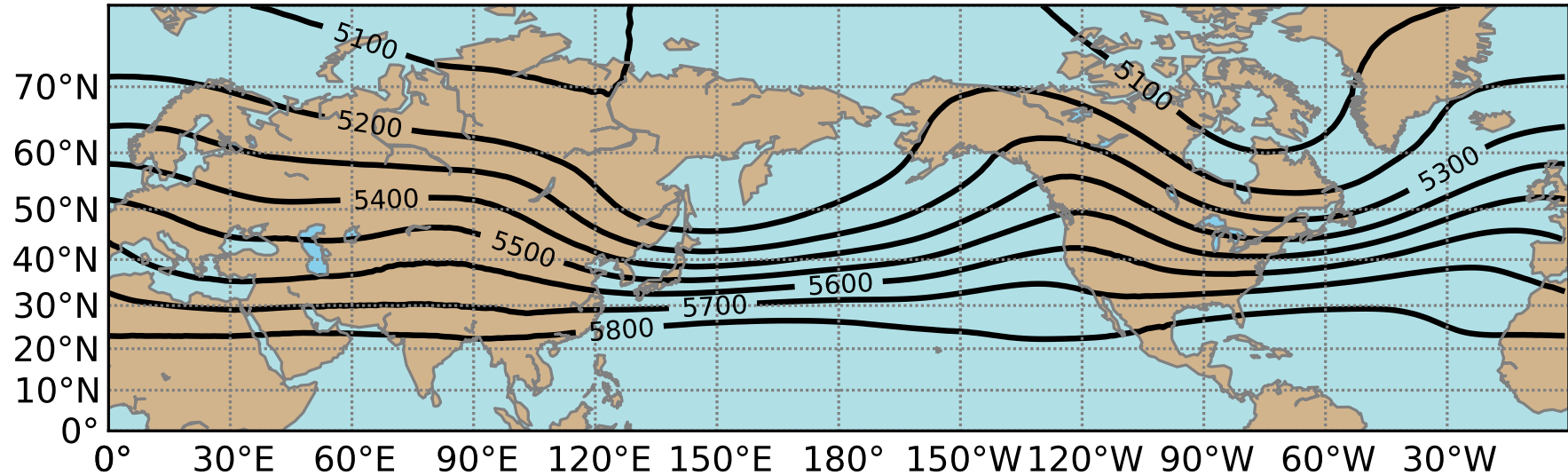


The first 10 years are much less skillful than the subsequent 18.

(a) Composite 500 hPa geopotential height under block at Lon = 180E

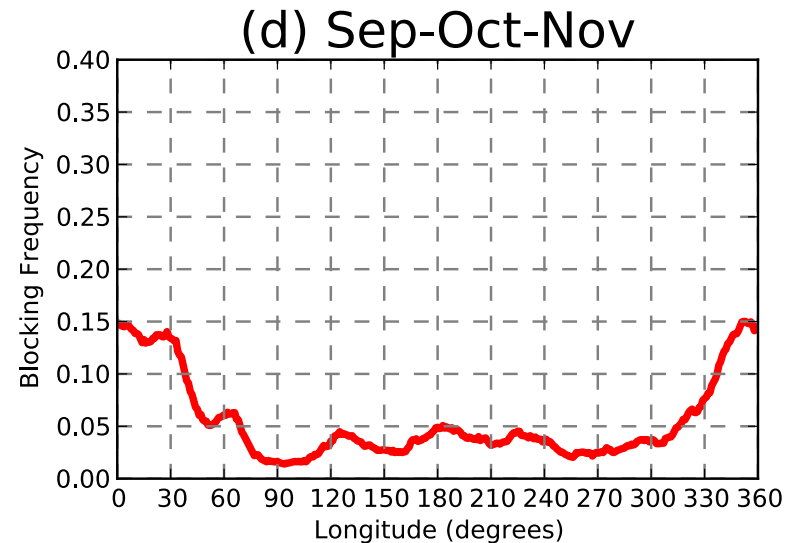
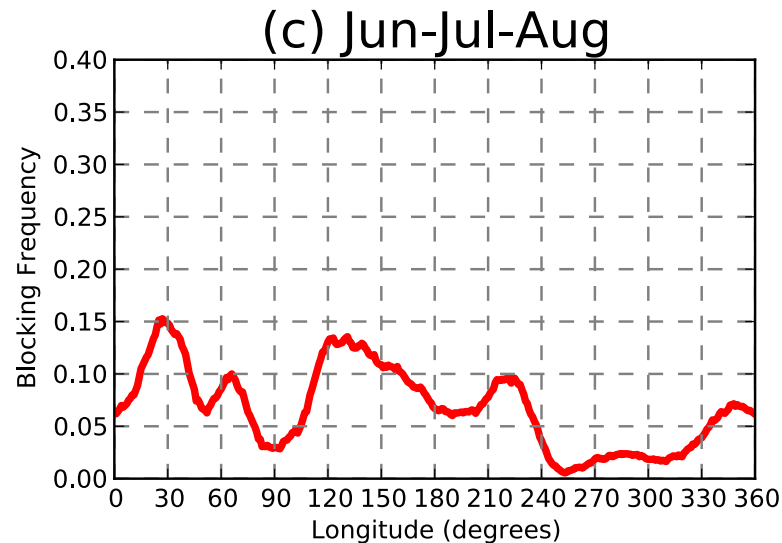
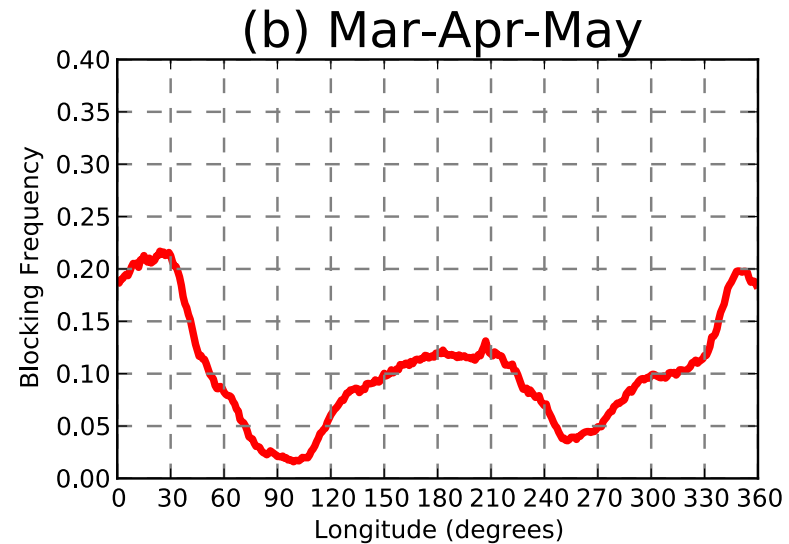
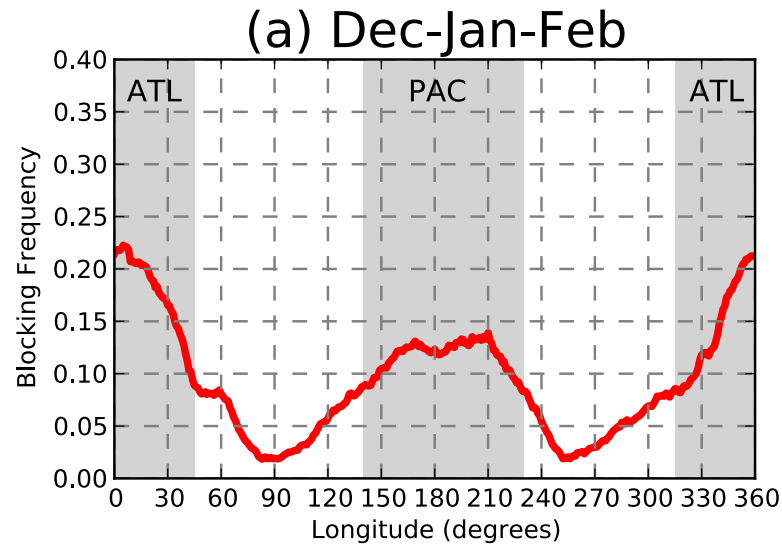


(b) Composite 500 geopotential height under no block at Lon = 180E



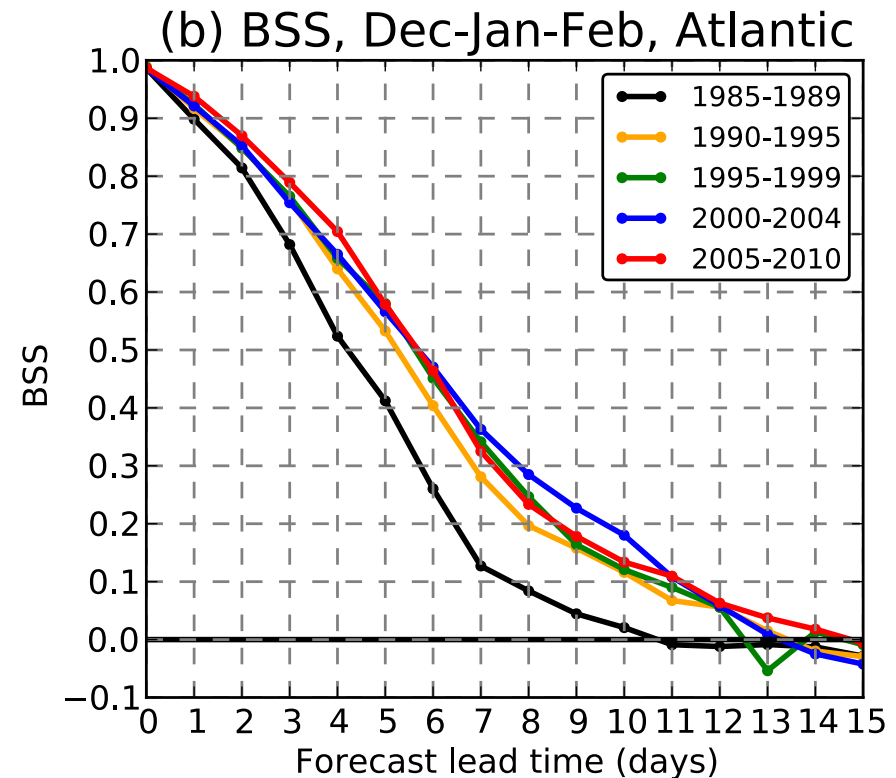
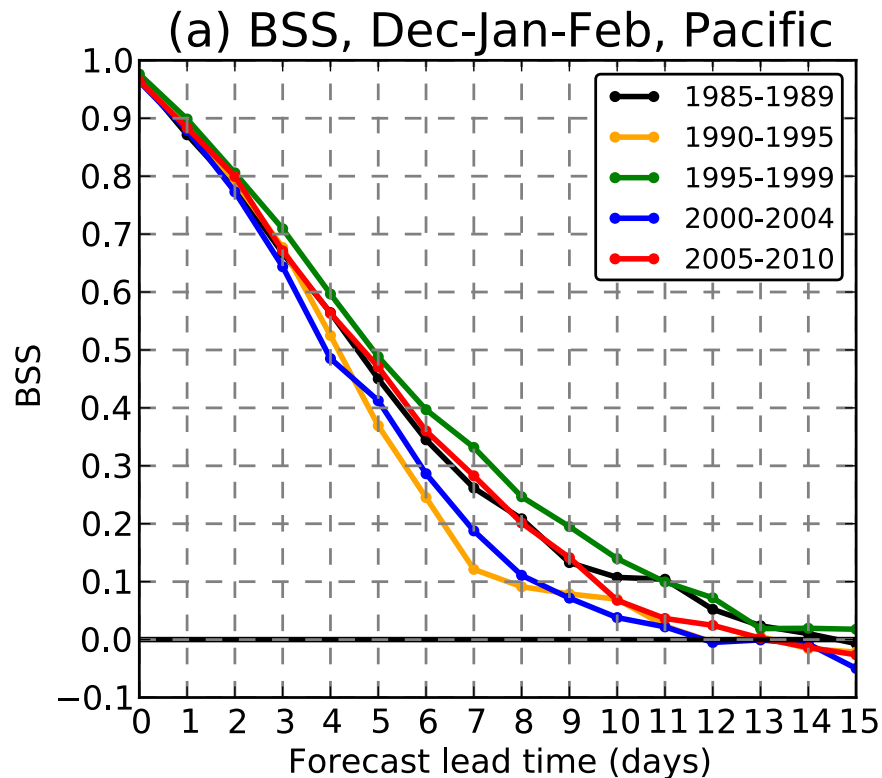
Dec-Jan-Feb 1985-2010 CFSR data. Blocks defined here by Tibaldi/Molteni algorithm.

N Hem. blocking: more common in winter, spring



Blocking as defined in Tibaldi and Molteni (1990) using Z500. In next slide, we focus on Dec-Jan-Feb. Grey bands defines Euro/Atlantic and Pacific blocking sectors in subsequent plots. 17

GEFS blocking skill by half decade

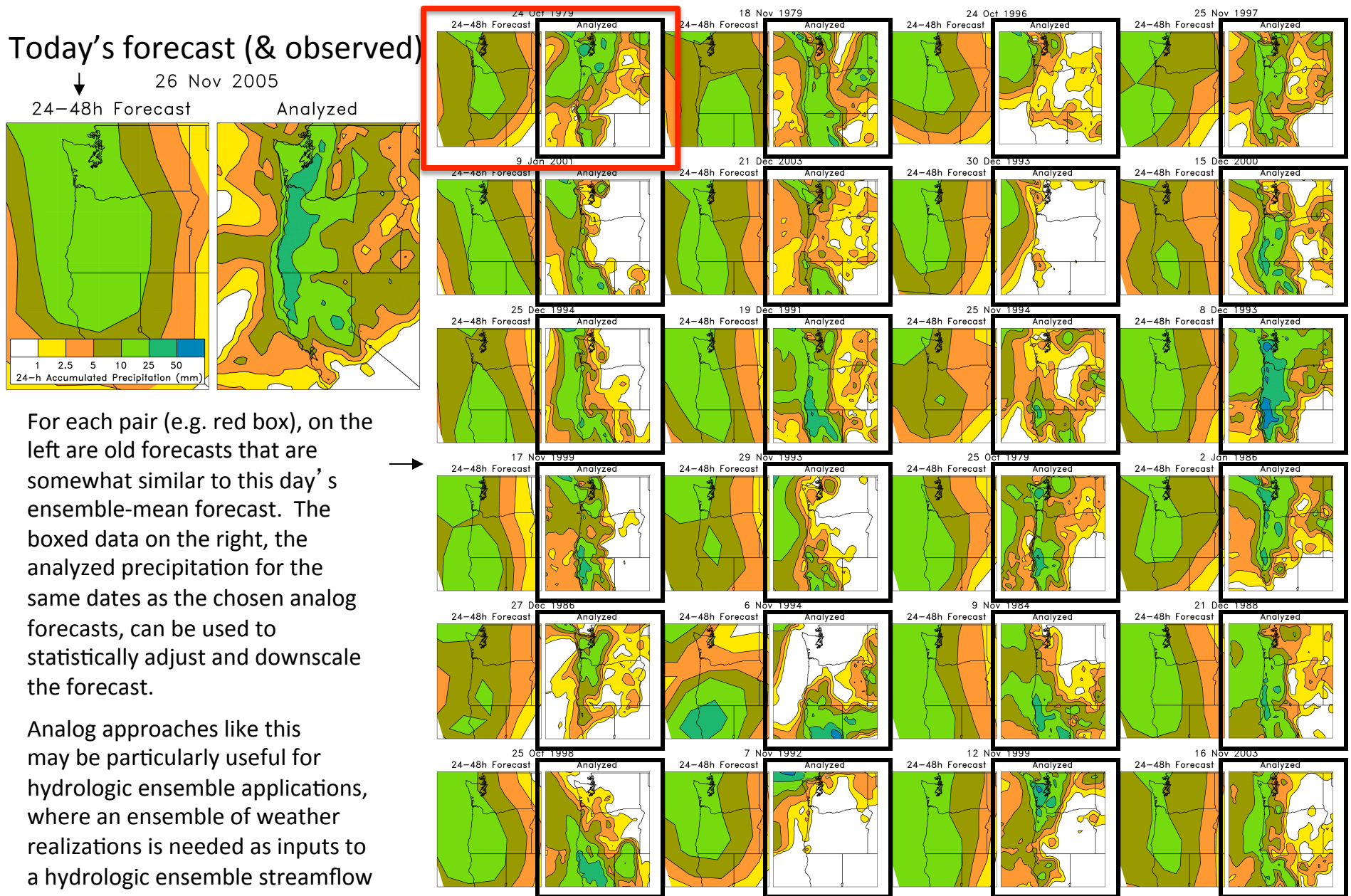


Blocking is evaluated using Tibaldi-Molteni algorithm for every longitude, every day. Skill of the ensemble in predicting blocking is then evaluated.

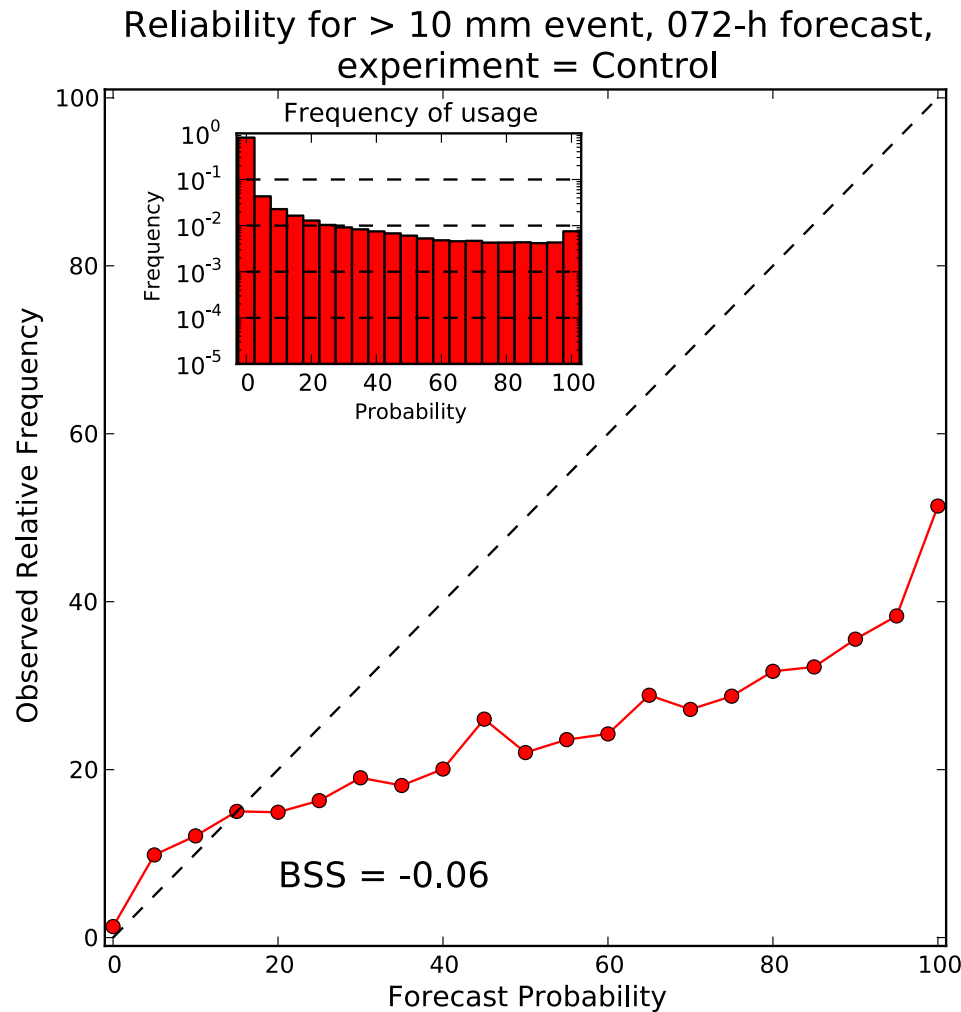
Decreased Atlantic sector skill in 1985-1989 period stands out.

Statistical post-processing using reforecasts

An example of a statistical correction technique using those reforecasts

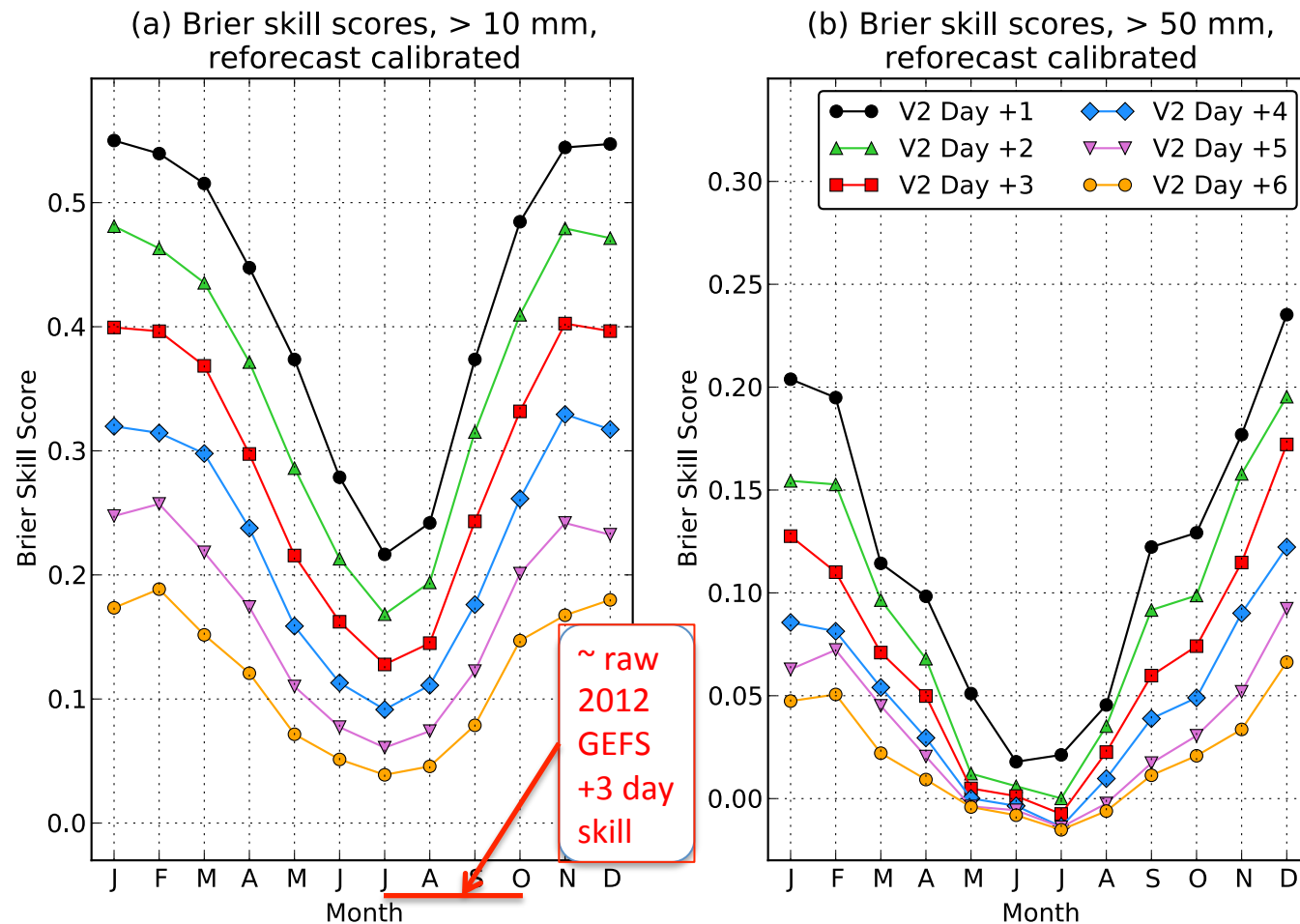


Forecasts evaluated operational 2012 GEFS for 2 Jul – 30 Sep 2012 (against CCPA analyses)



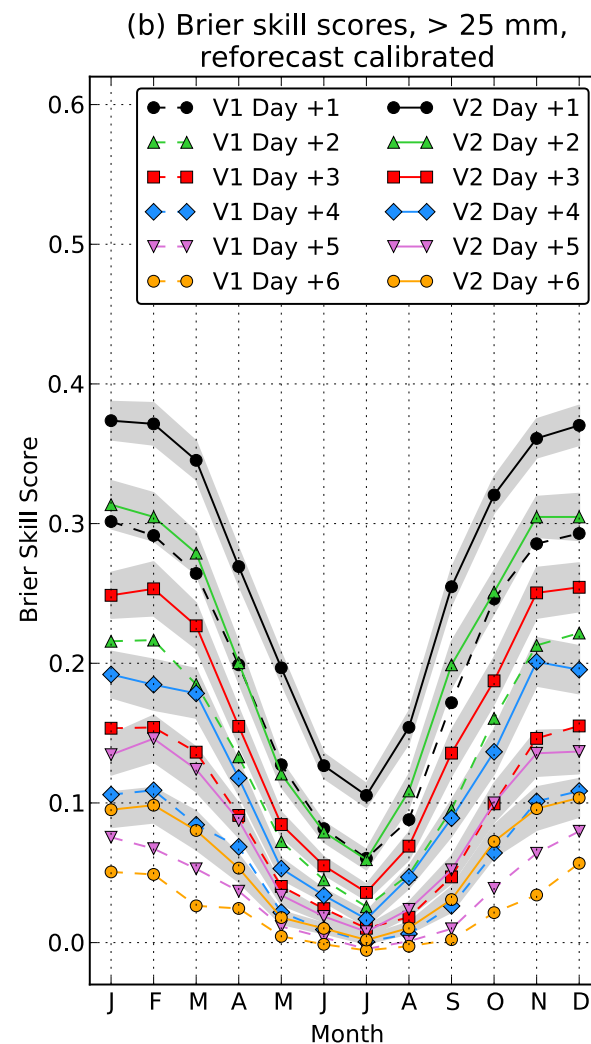
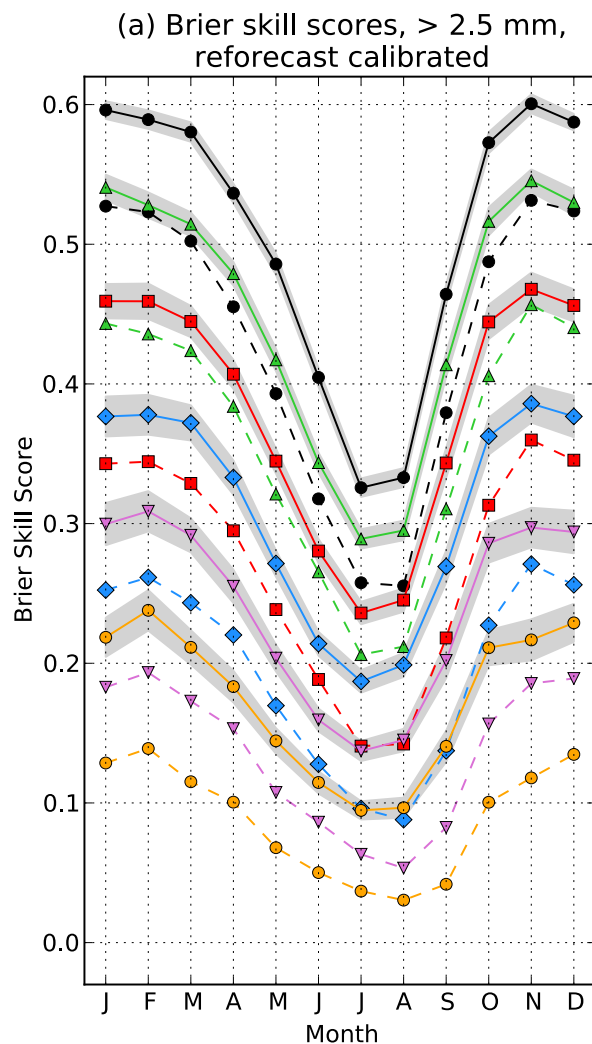
Here, the 21-member ensemble forecasts are validated against the 1-degree NCEP CCPA precipitation analysis, which regresses Stage IV data against the Higgins precipitation analysis.

Skill of calibrated precipitation forecasts (over US, 1985-2010, “rank analog” calibration method)



Verification here against 32-km North American Regional Reanalysis (tougher).
Verification in previous plot against 1-degree NCEP precipitation analysis (easier).

How do v2 2012 reforecast-calibrated precipitation forecasts compare to the v1, 1998 reforecast-calibrated?



solid lines are reforecasts from the 2012 GEFS

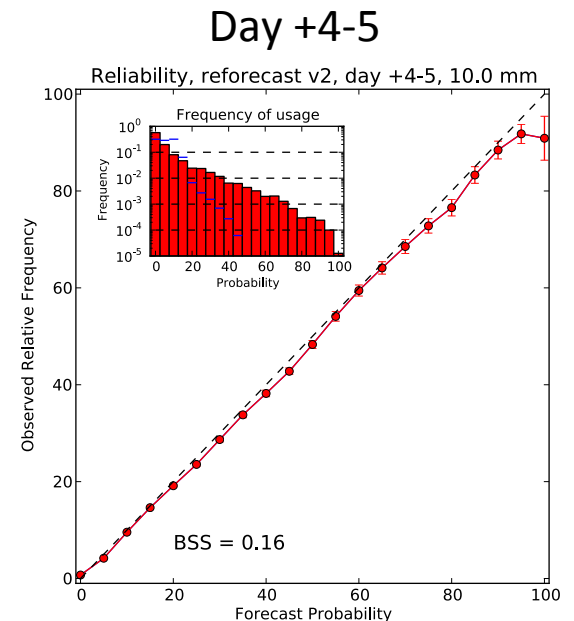
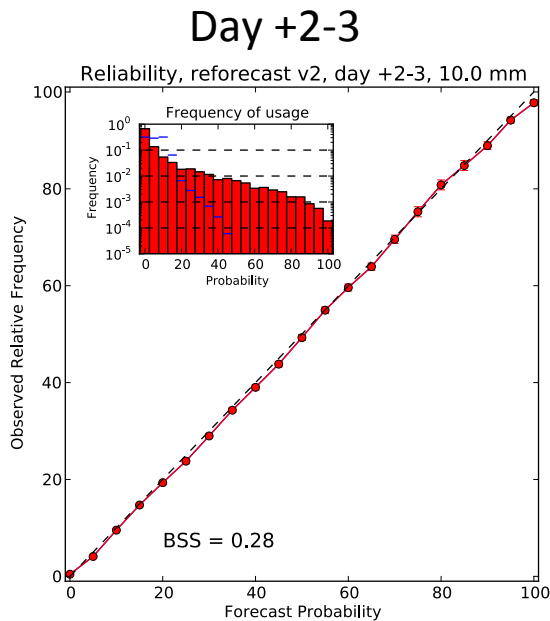
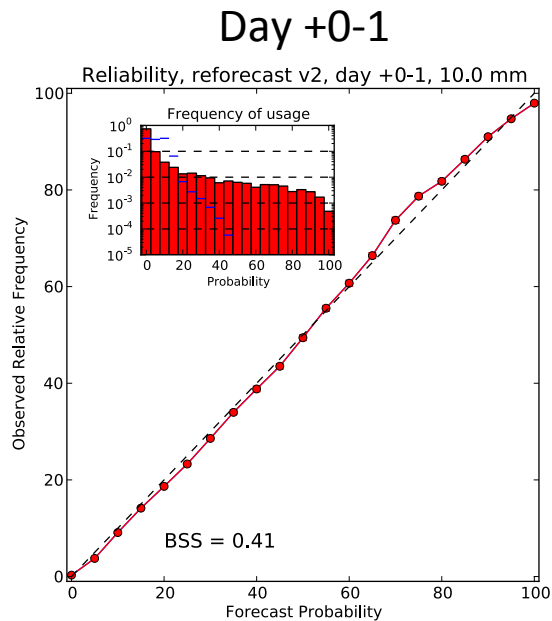
dashed lines are reforecasts from the 1998 GEFS

gray bars are the 5-95% confidence intervals.

verified against NARR over CONUS 1985-2012.

Reliability, > 10 mm precipitation 24 h⁻¹

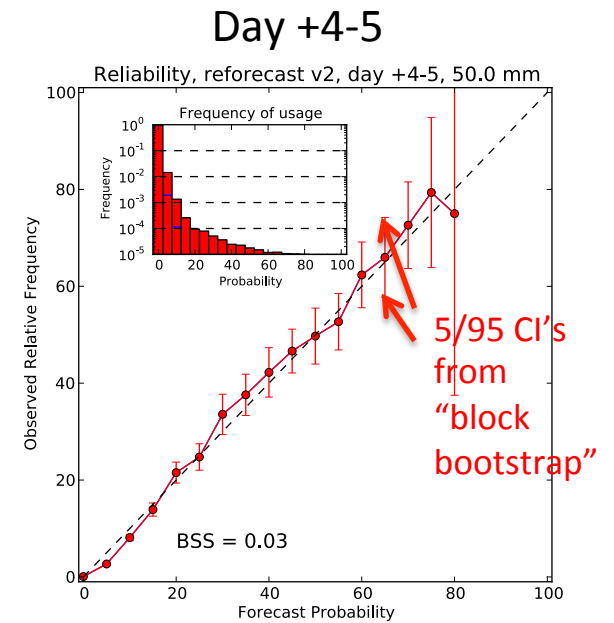
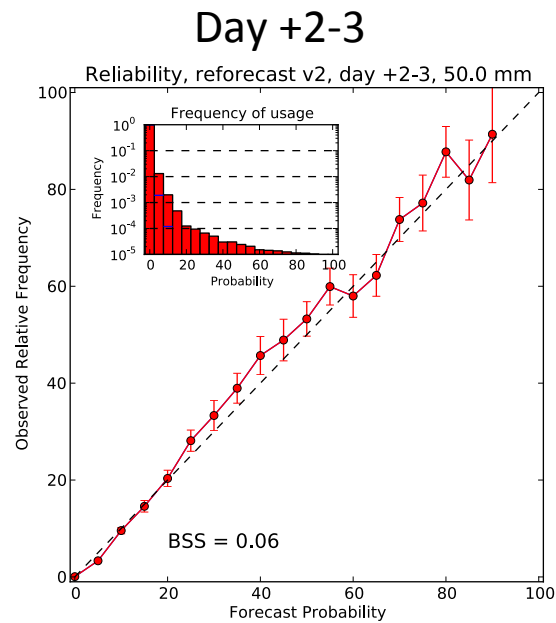
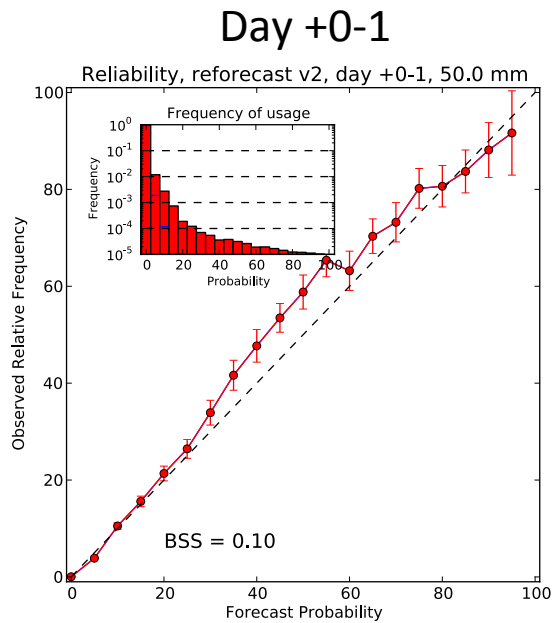
Version 2 (2012 GEFS)



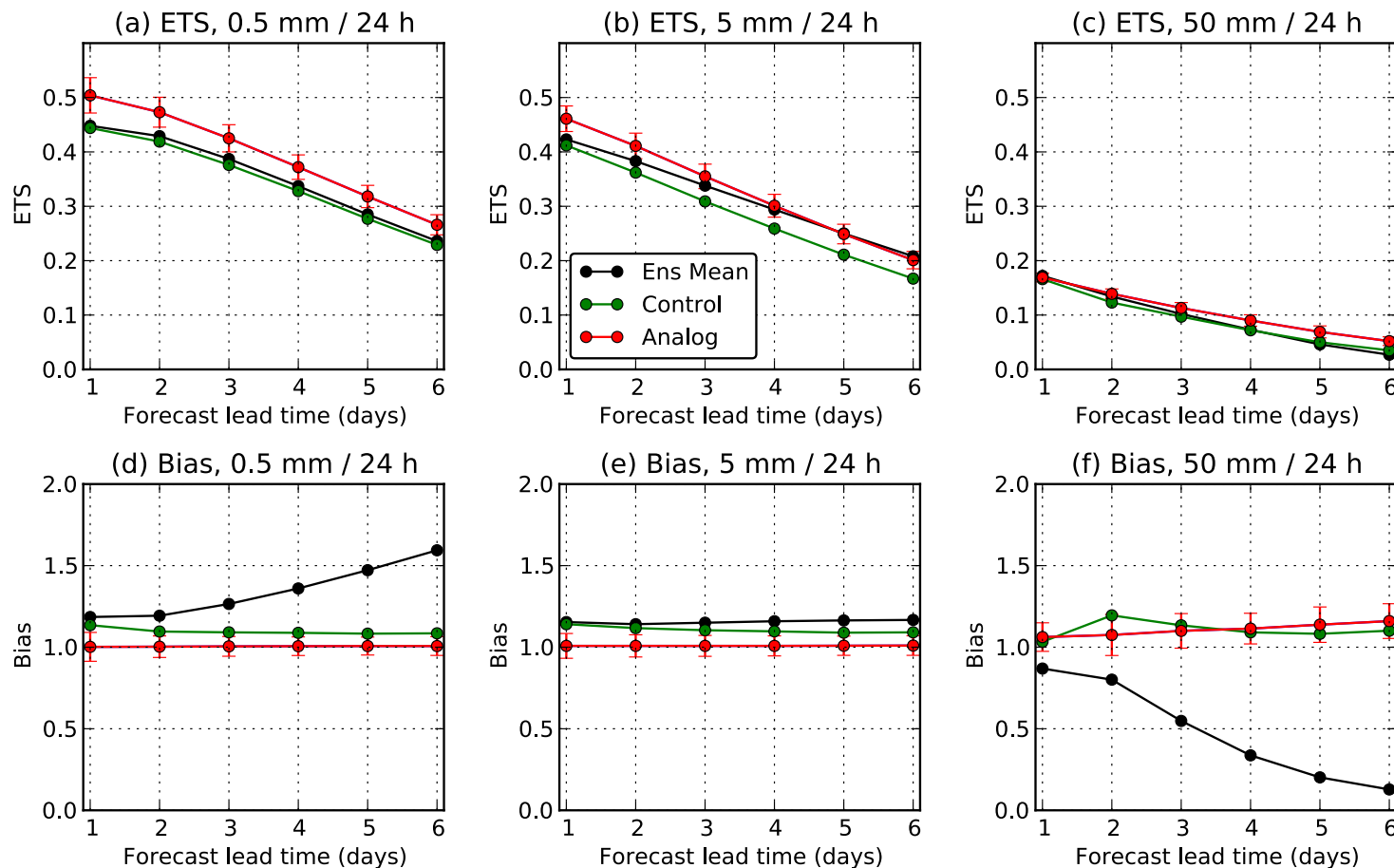
Almost perfect reliability.

Reliability, > 50 mm precipitation 24 h^{-1}

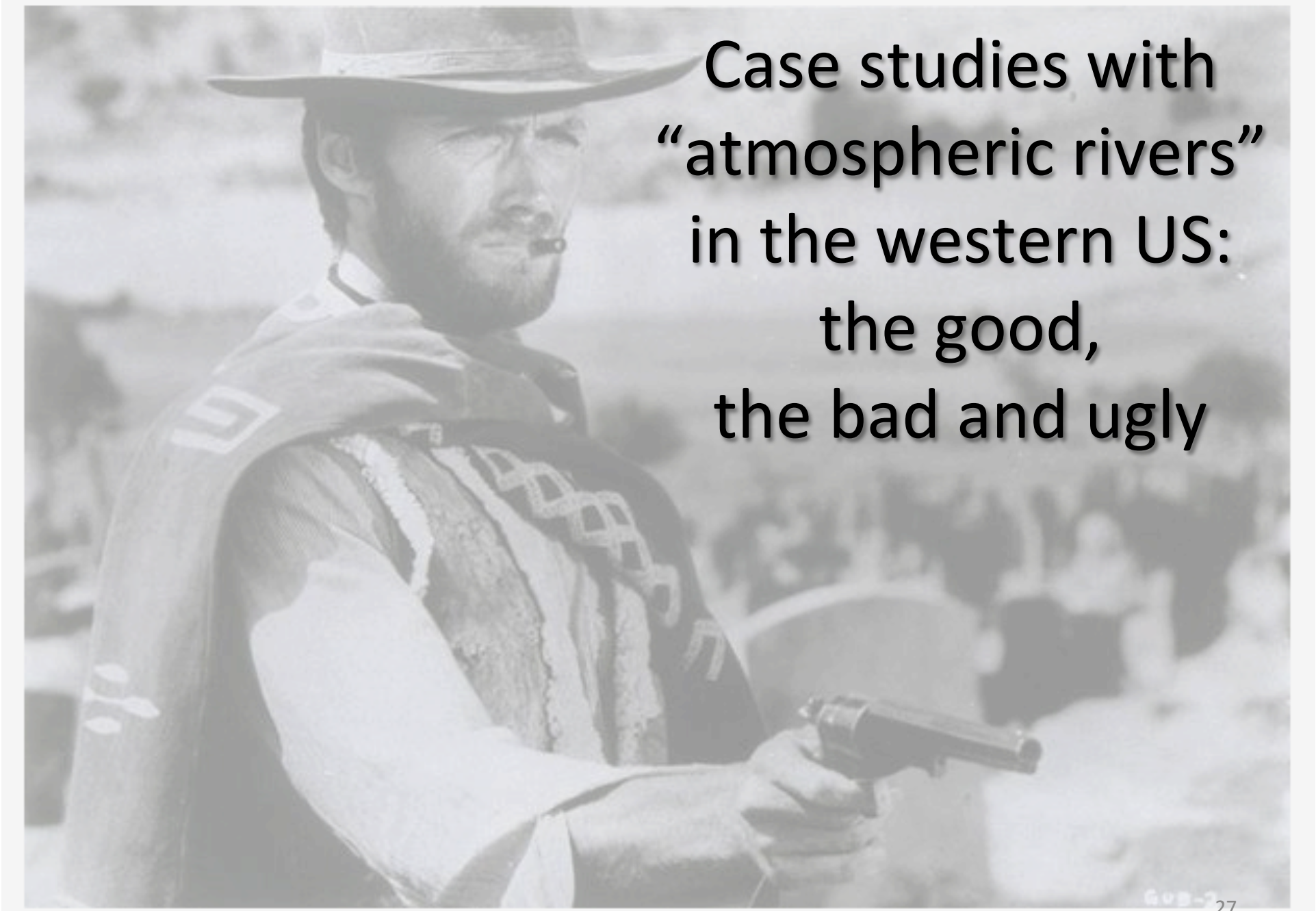
Version 2 (2012 GEFS)



Post-processing to improve deterministic forecasts



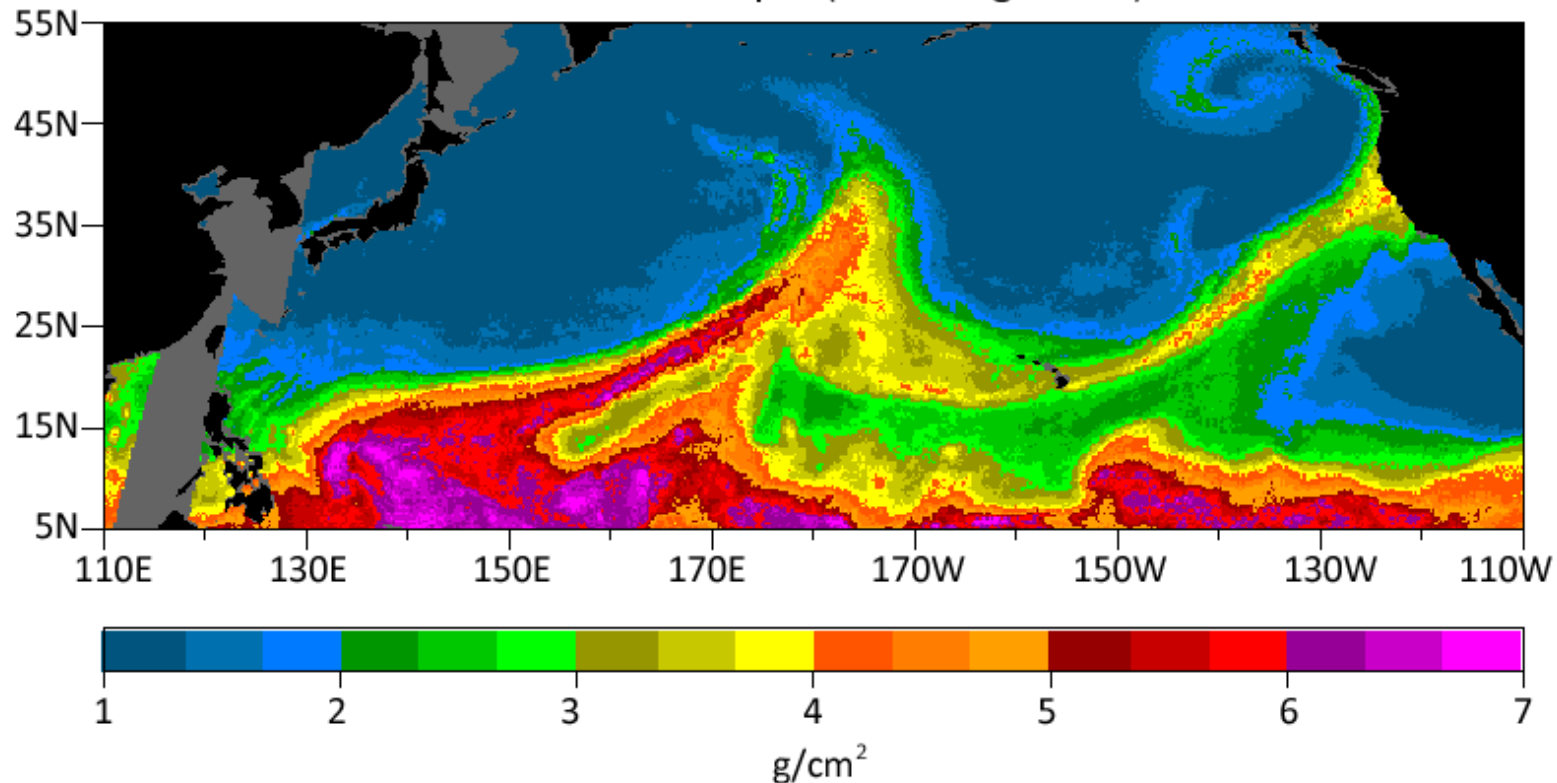
Some further modifications to analog technique, including Ebert's "probability-matched mean" approach allow post-processed forecasts to improve significantly on deterministic forecast guidance supplied by the model.



Case studies with
“atmospheric rivers”
in the western US:
the good,
the bad and ugly

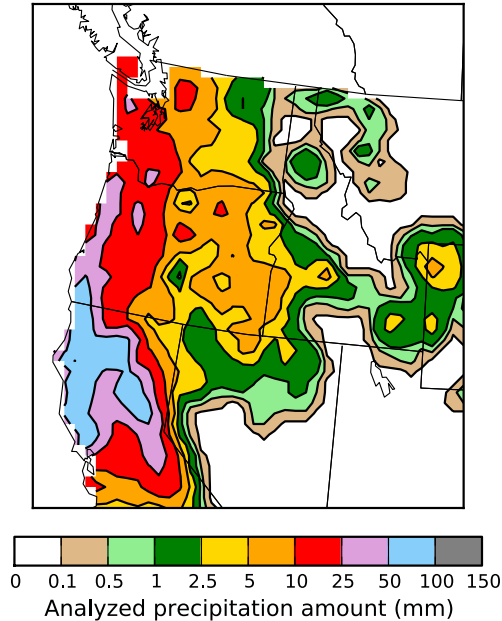
The bad and ugly atmospheric rivers case study

February 16, 2004 12-24 UTC
SSM/I Water Vapor (Wentz algorithm)

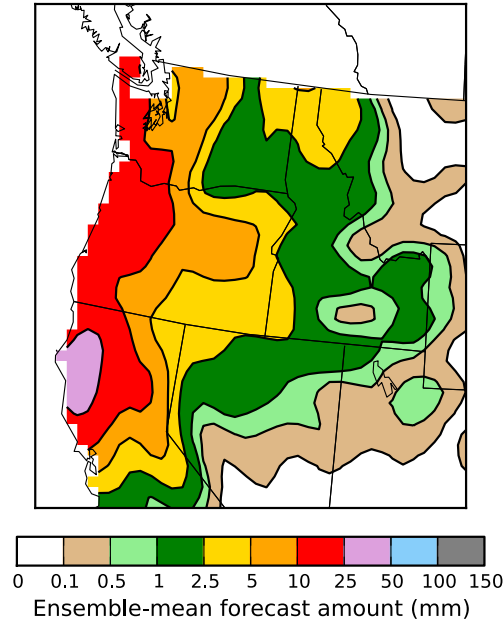


➤ 10" rain in the coastal mountains, 4-7" in Russian River watershed. Streamflows in top 0.2% of historical observations.

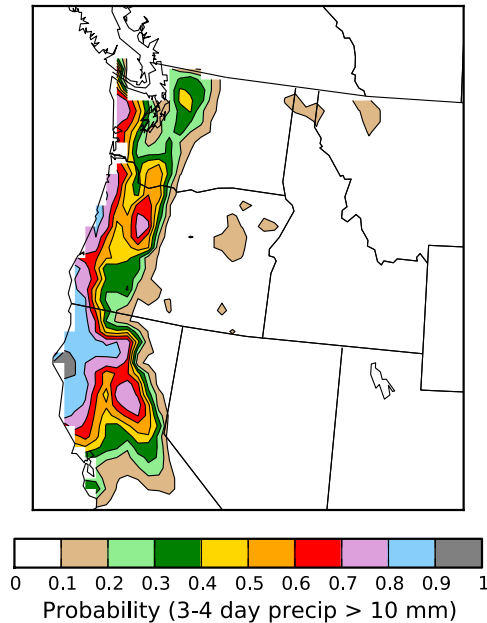
(a) 24-h accumulated precip analysis,
VT = 2004021700



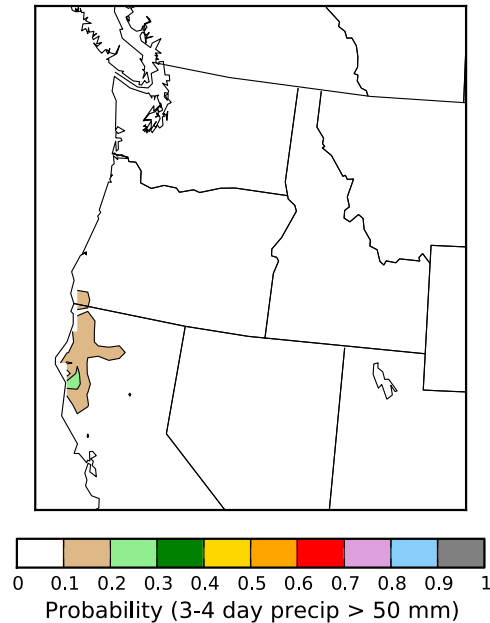
(b) 3-4 day mean forecast,
Reforecast v2, VT = 2004021700



(c) P(3-4 day accum precip > 10 mm),
Reforecast v2, VT = 2004021700

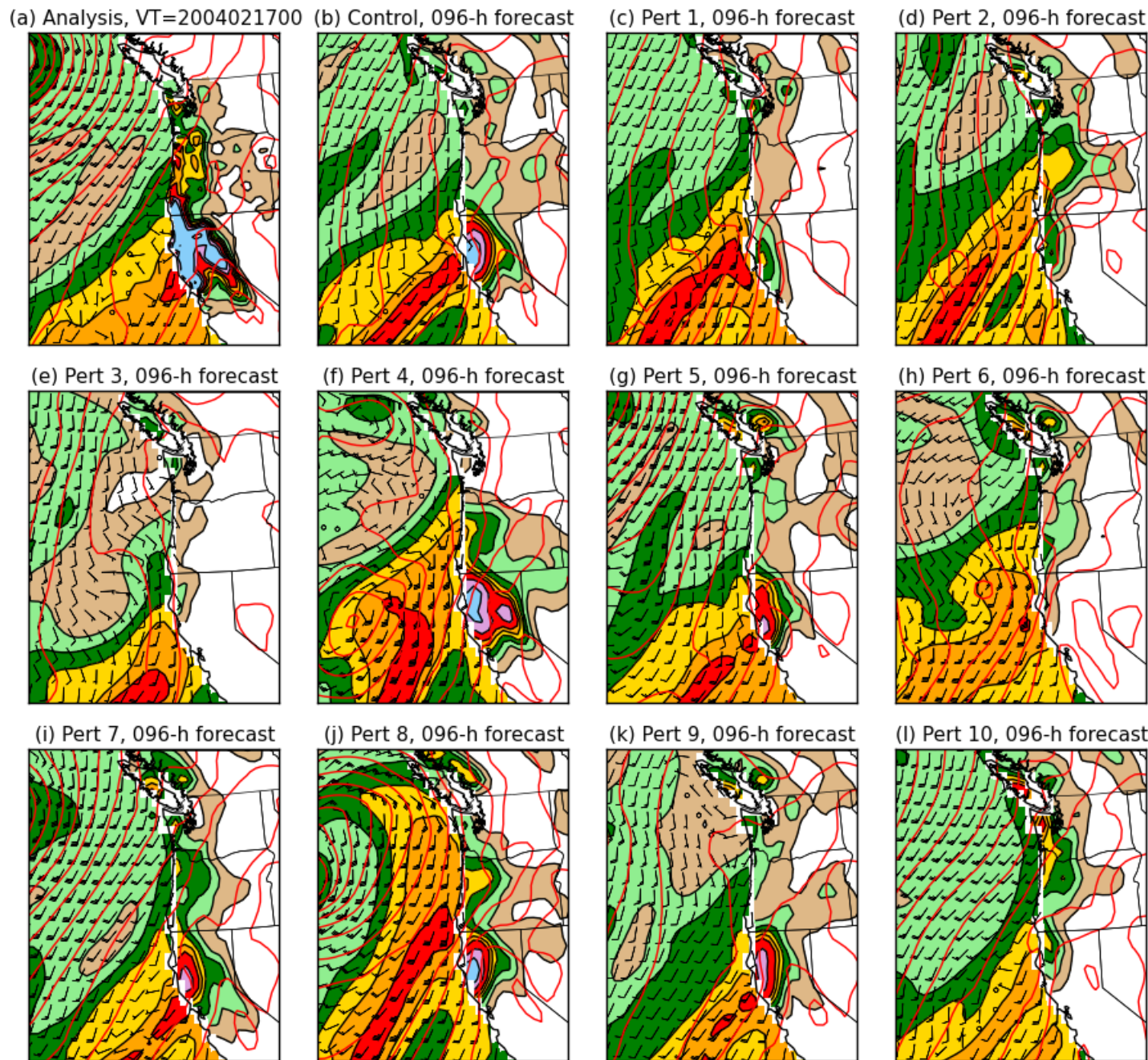


(d) P(3-4 day accum precip > 50 mm),
Reforecast v2, VT = 2004021700



+4-day
forecast

very little hint of excessive
rainfall in post-processed
guidance over N CA.



+4-day forecast

Colors: over the ocean, the total-column precipitable water. Over land, the 24-h accum. precipitation.

Wind barbs for the 925 hPa level.

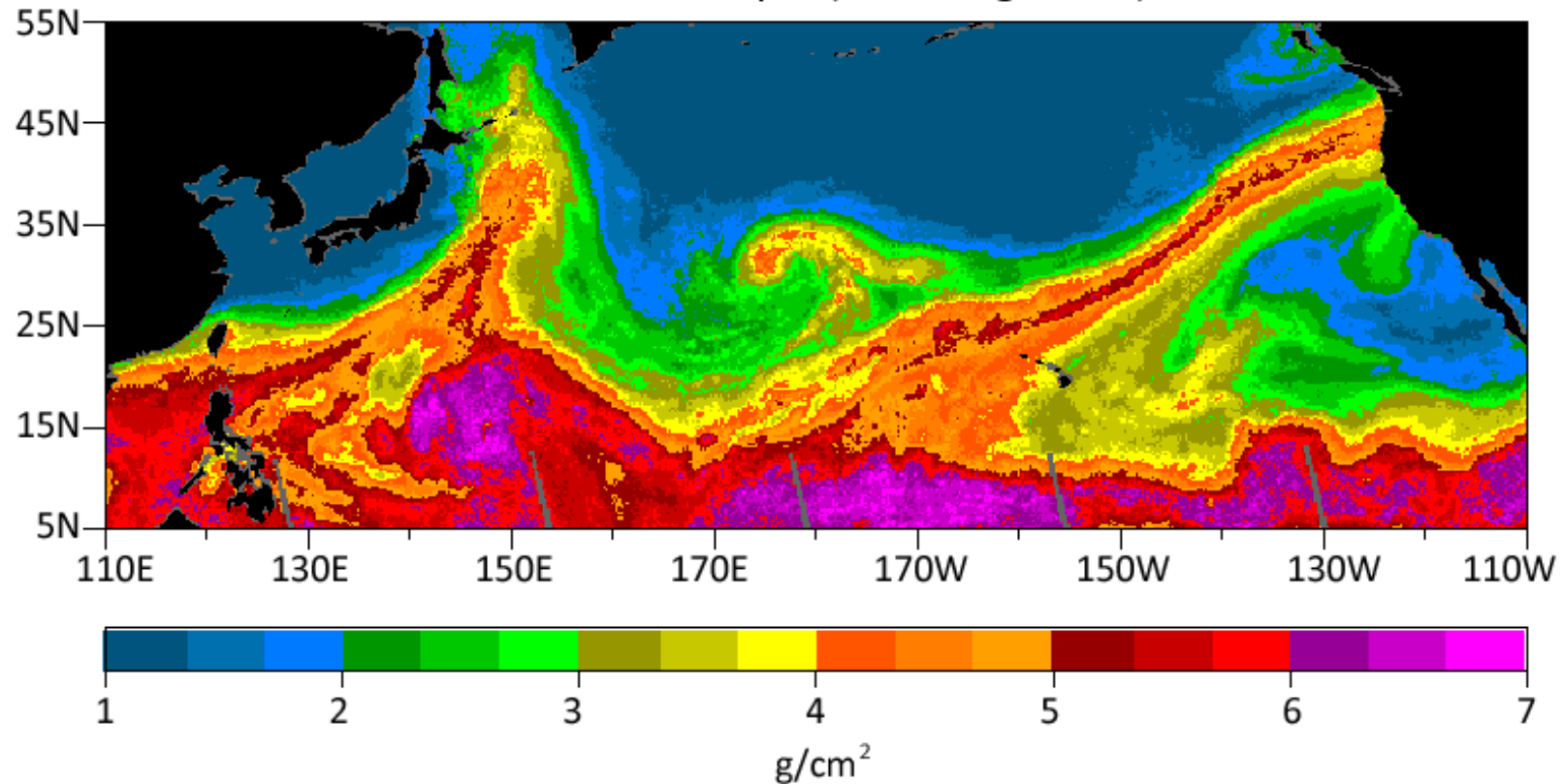
Red contours: mean sea-level pressure.

Lesson: garbage in, garbage out.

The “good” atmospheric rivers case study: Nov 2006 Oregon-Washington floods

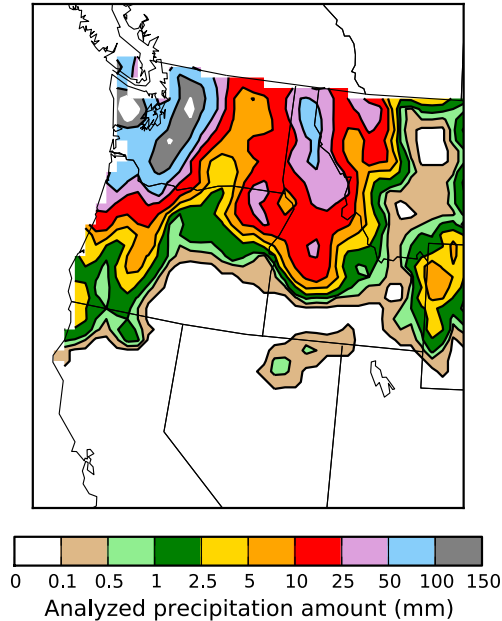
November 07, 2006 00-12 UTC

SSM/I Water Vapor (Wentz algorithm)

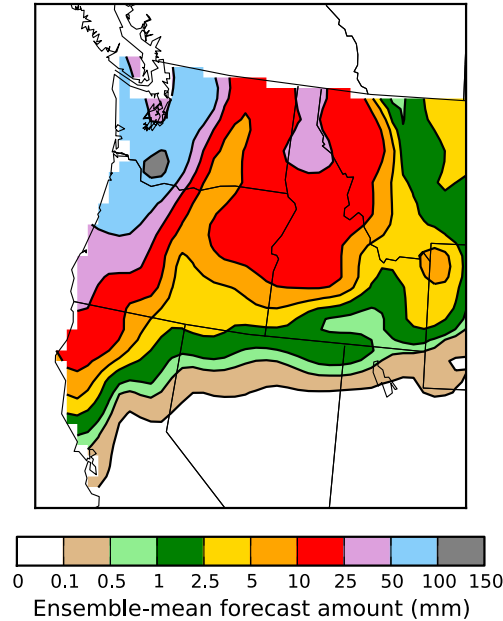


8-20 inches of rain in Cascades; flooded rivers; extensive damage to Mt. Rainier NP.

(a) 24-h accumulated precip analysis,
VT = 2006110700

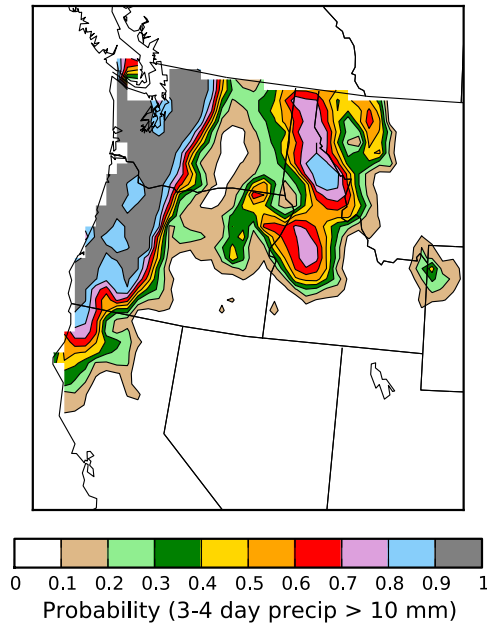


(b) 3-4 day mean forecast,
Reforecast v2, VT = 2006110700

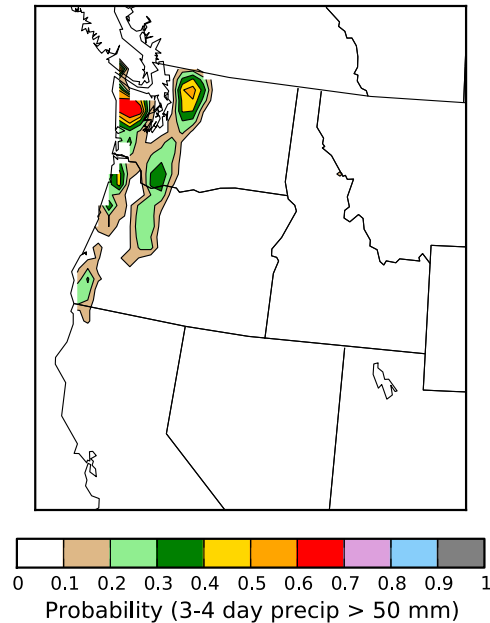


+4-day
forecast

(c) P(3-4 day accum precip > 10 mm),
Reforecast v2, VT = 2006110700

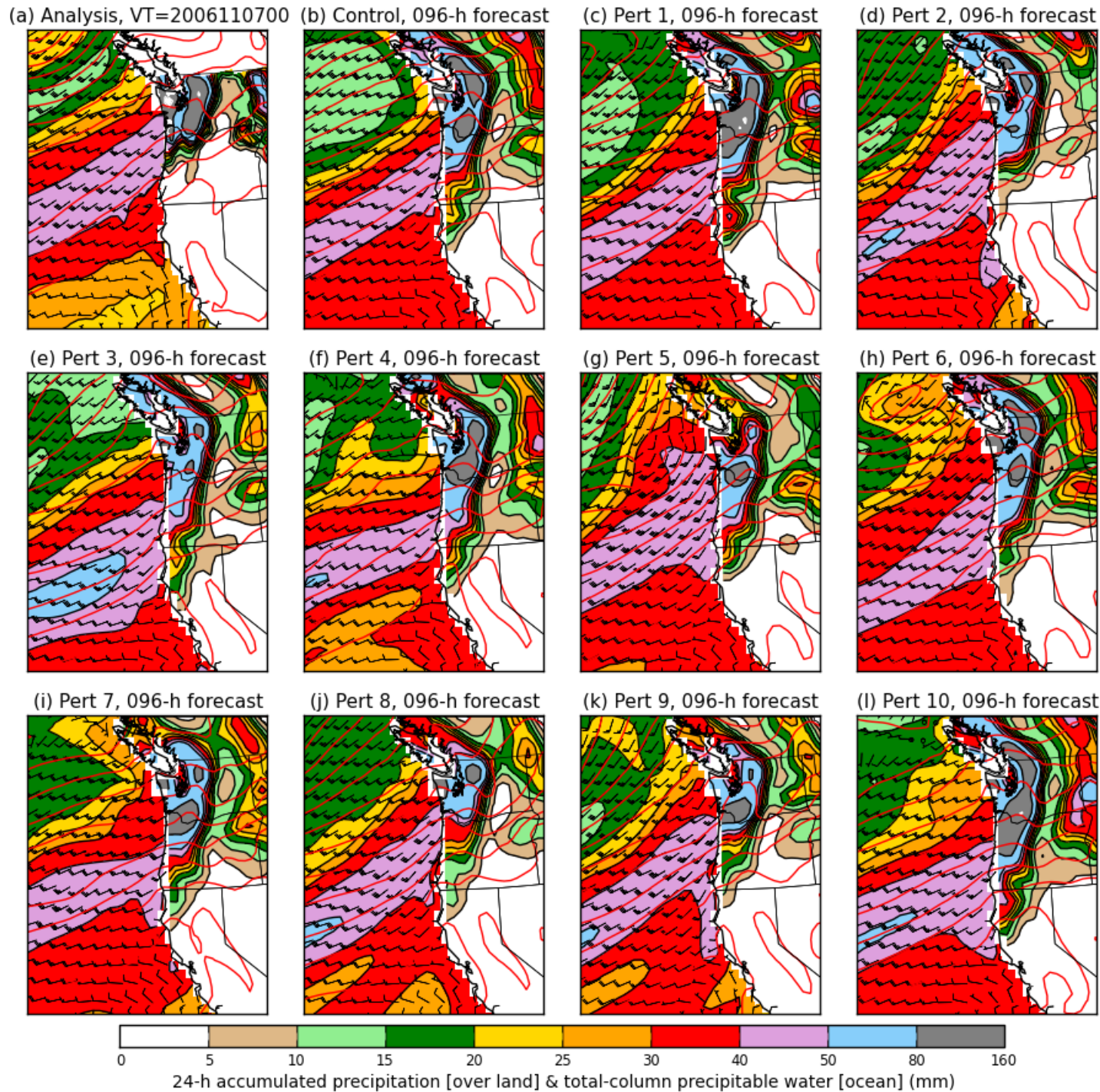


(d) P(3-4 day accum precip > 50 mm),
Reforecast v2, VT = 2006110700



Now there are reasonably
high probabilities of heavy
precipitation.

+4-day
forecast

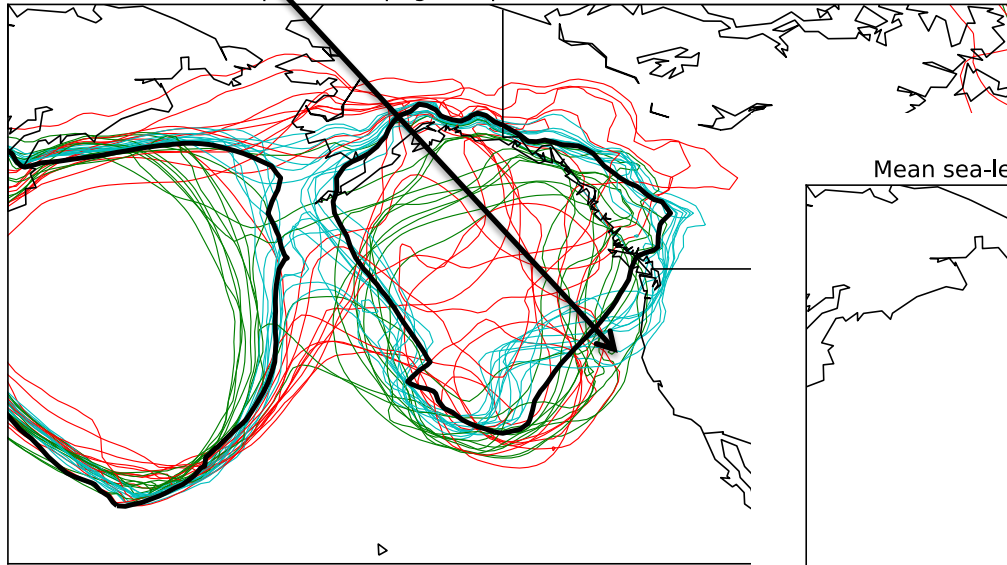


Spaghetti Westerns

Inconsistent forecasts of orientation of isobars and hence wind direction

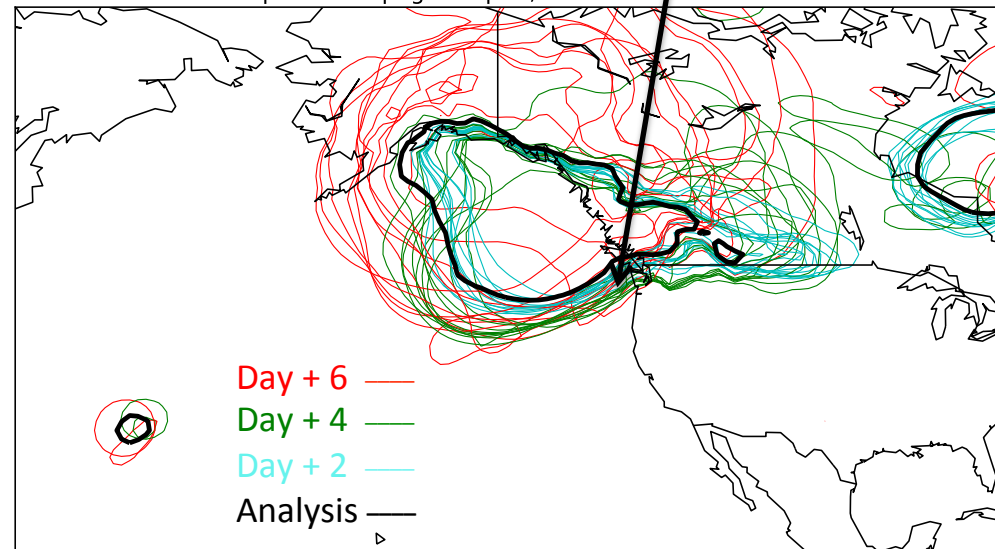
Consistent forecasts of orientation of isobars and hence wind direction

Mean sea-level pressure spaghetti plot, VT = 2004021700 contour = 1004



The bad and the ugly

Mean sea-level pressure spaghetti plot, VT = 2006110700 contour = 1000



The good

Reforecast precipitation product web page

The screenshot shows a web browser window with the URL www.esrl.noaa.gov/psd/forecasts/reforecast2/analog/index.html. The page header includes the NOAA logo and the text "U.S. Department of Commerce | National Oceanic & Atmospheric Administration | NOAA Research". Below this is the "Earth System Research Laboratory Physical Sciences Division" banner. A search bar labeled "Search PSD:" is on the right. A navigation menu includes "Physical Sciences Division", "About", "Contact", "Research", "Data", "Products", "Outreach", and "Intranet".

The main content area is titled "Precipitation Forecast Products Based on NCEP GEFS Reforecasts, Version2". It contains the following text:

This page presents experimental precipitation forecasts, including deterministic and probabilistic forecast information produced with a rank-analog technique similar to the one described in [Hamill and Whitaker \(2006\)](#). It also presents graphical forecast products similar to ECMWF's [Extreme Forecast Index](#). More detailed information on both is available [here](#).

These forecasts will usually (but not always) be updated by 12 UTC each day. They likely will not be available as consistently as operational products from the National Weather Service. Also please note that this is an experimental forecast product, and is not an official forecast of NOAA or its National Weather Service. Precipitation units are mm (25.4 mm = 1 inch).

We welcome feedback on this product. E-mail comments to: esrl.psd.data@noaa.gov.

Below the text is a section titled "Choose a Forecast Plot Below:" with the following form elements:

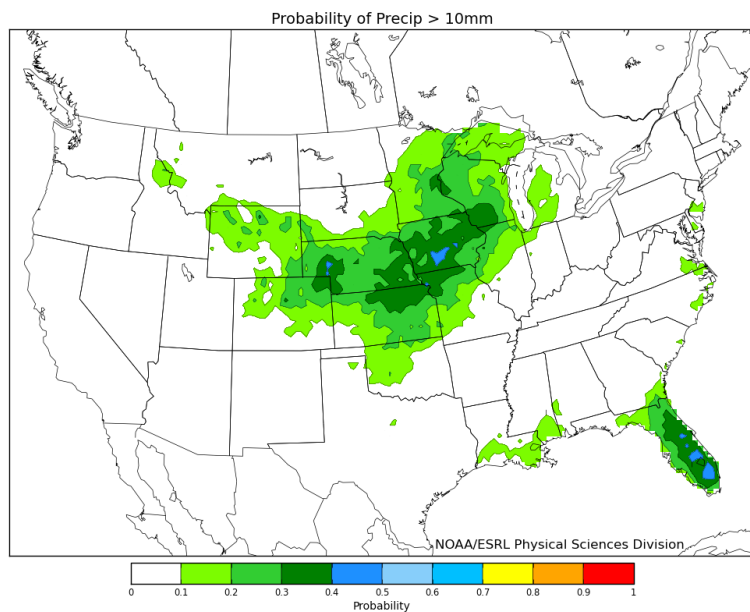
- Analysis Date** (format: *yyyymmdd*): Please input a date within last 7 days: [show today](#)
- Forecast Period**:
- Plot Type**:
-

A left sidebar contains navigation links for "Reforecast2 Project", "PSD Branches", "ESRL Divisions", and "Program Links".

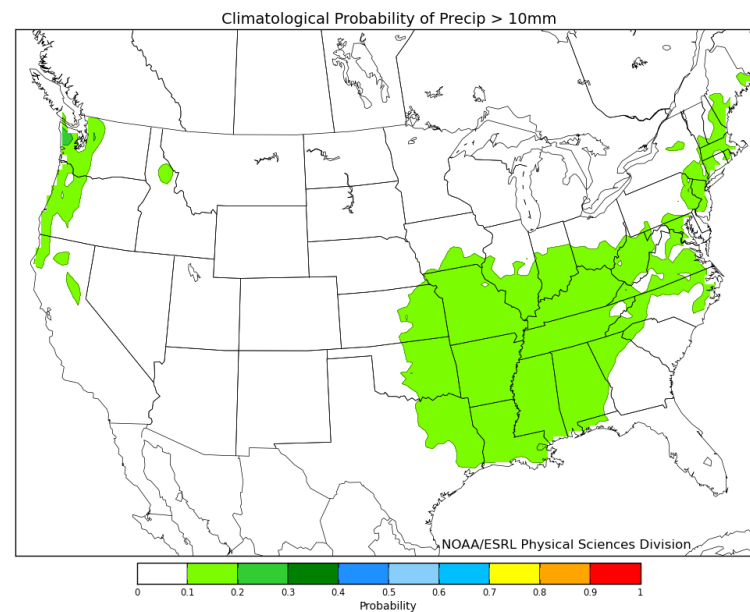
<http://www.esrl.noaa.gov/psd/forecasts/reforecast2/analog/index.html>

Probability of > 25 mm, 72-144 h forecast from 00Z Tuesday, 17 April 2013

120-144hr fcst from 00Z Wed Apr 17. Valid 00Z Mon Apr 22 - 00Z Tue Apr 23
Calibrated with 1985-2010 Reforecast2 data.



120-144hr fcst, April
From 1985-2010 NARR data.

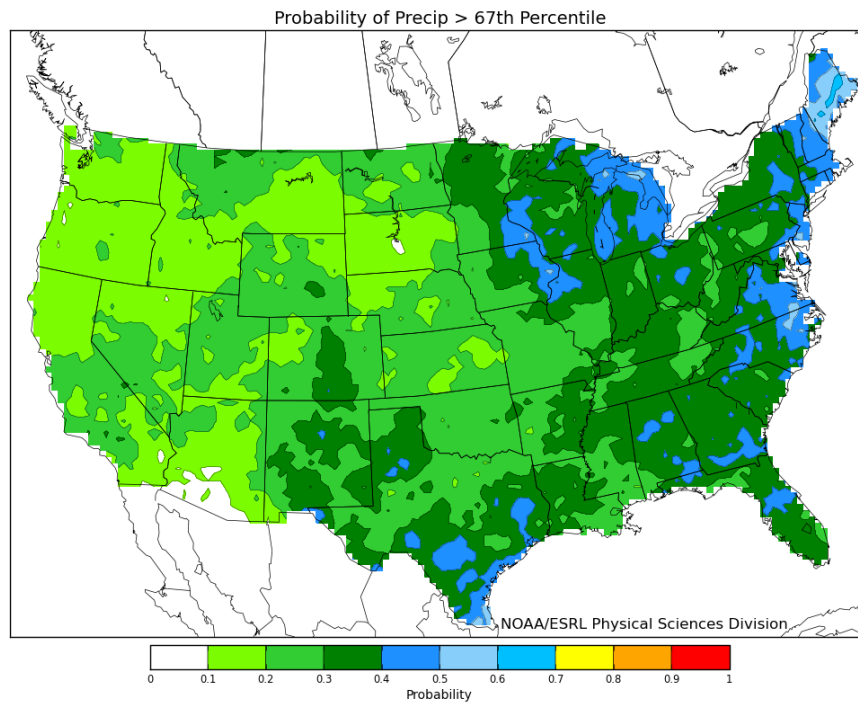


<http://www.esrl.noaa.gov/psd/forecasts/reforecast2/analog/index.html>

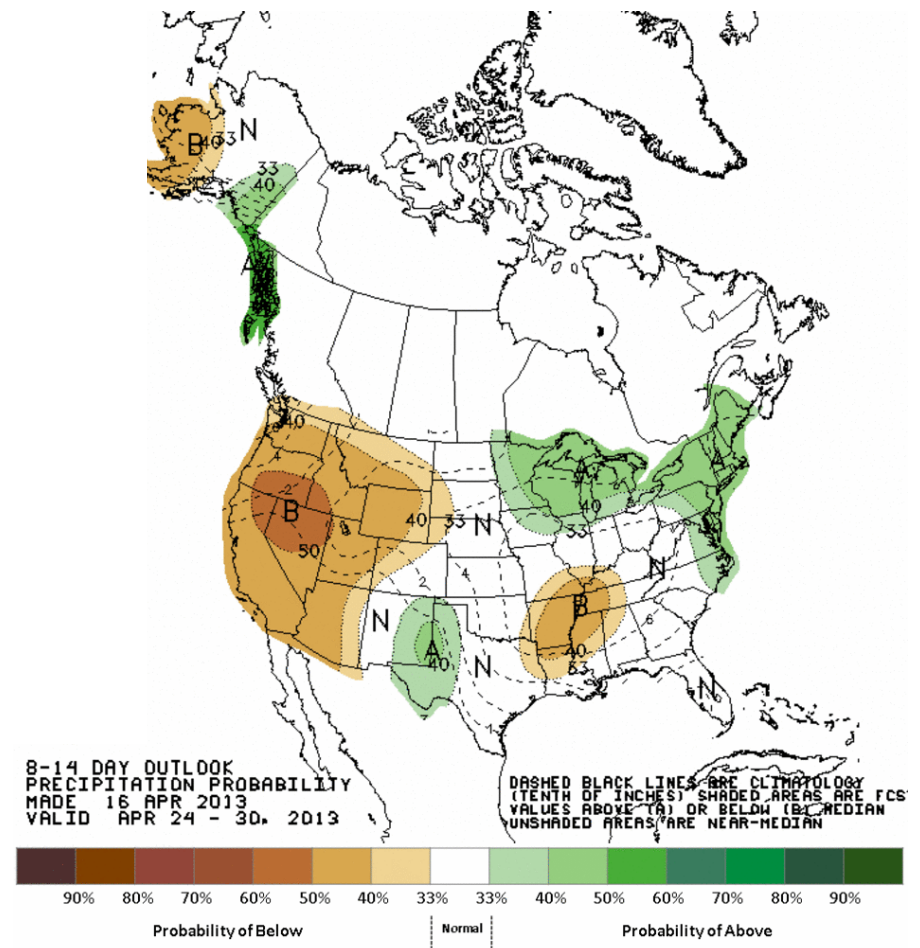
Week-2 forecast, P(precip > upper tercile)

168-336hr fcst from 00Z Wed Apr 17. Valid 00Z Wed Apr 24 - 00Z Wed May 01

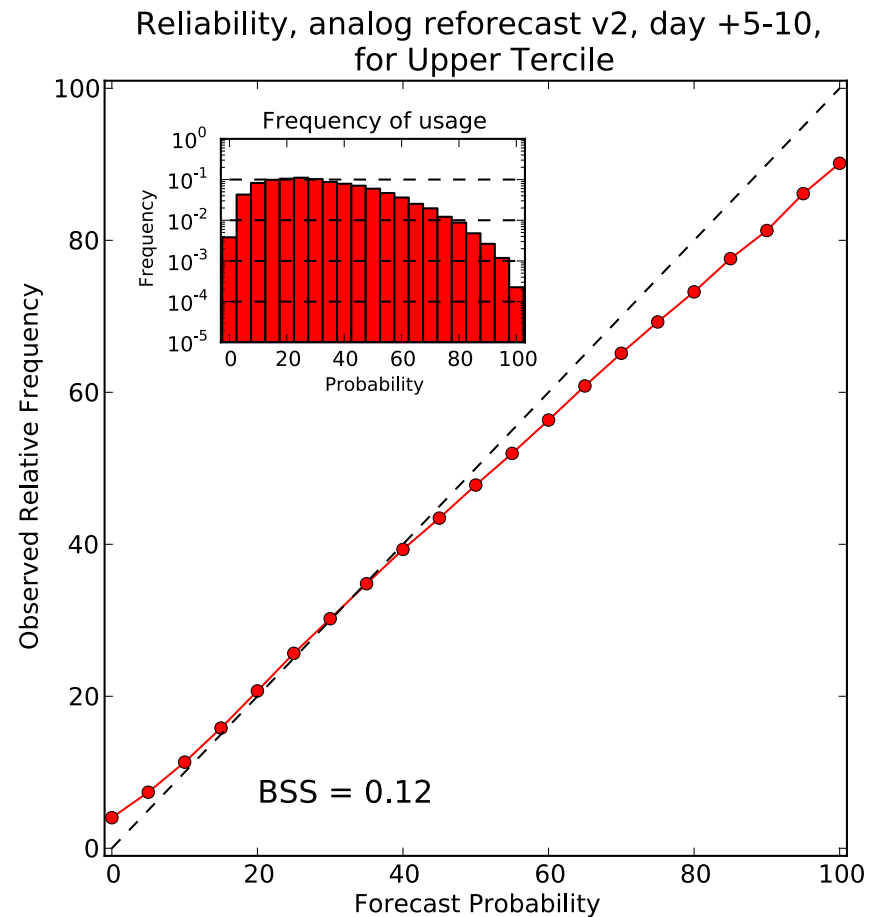
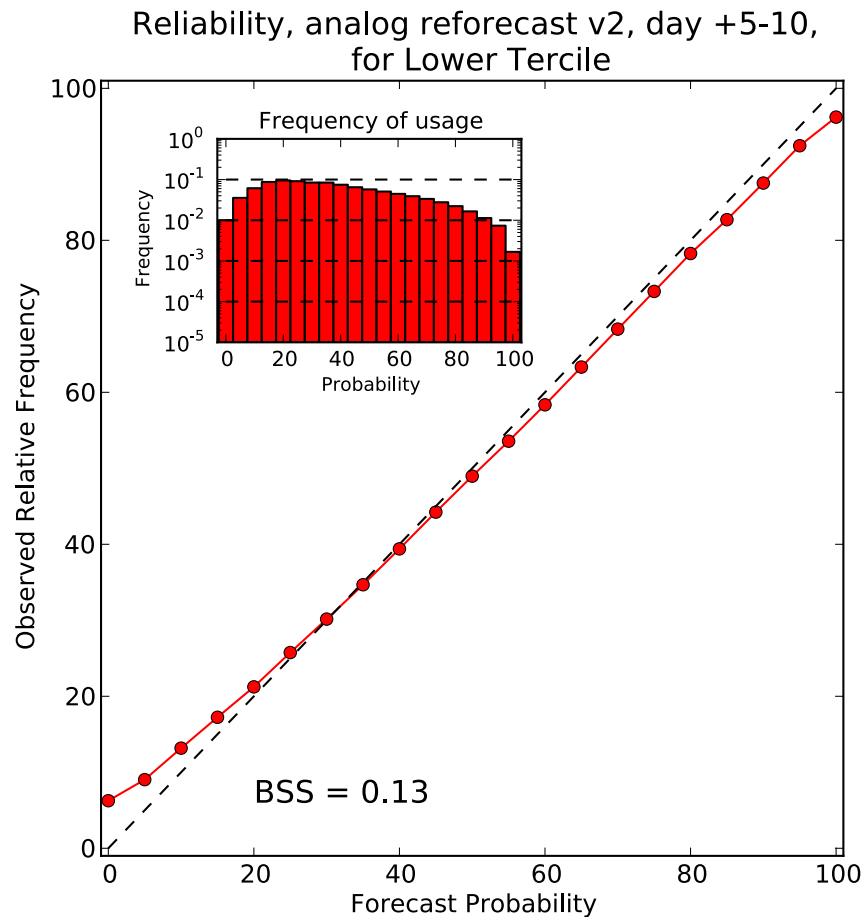
Calibrated with 1985-2010 Reforecast2 data.



Note: times don't match up exactly here;
CPC created during the day yesterday,
ours created overnight.



Post-processed precipitation reliability, upper and lower tercile, days 5-10 (120-240 h lead)



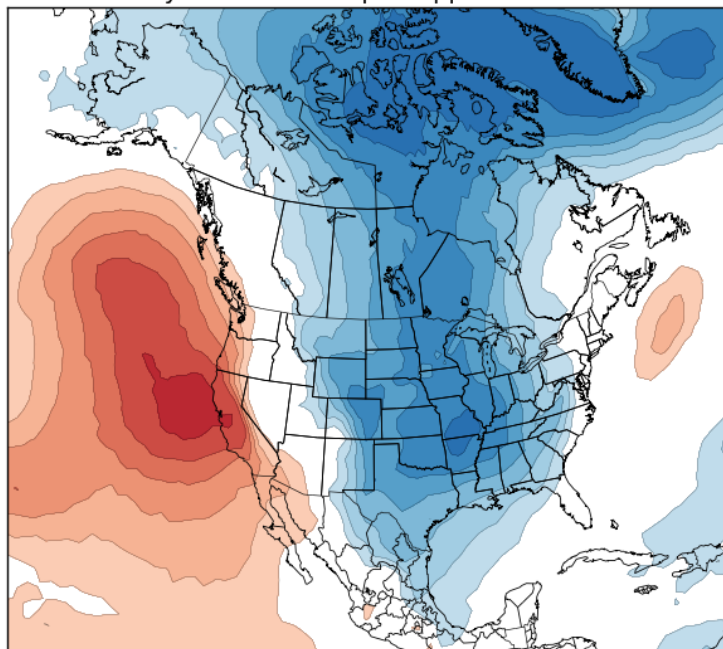
Comparatively, in our 2004 MWR article, for version-1 reforecasts validated against station data, 6-10 day RPS skill was ~ 0.06 .

Also: T2m, T850, Z500 calibrated forecast information

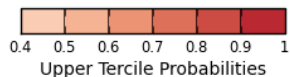
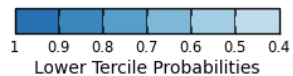
120-240hr fcst from 00Z Wed Apr 17.
Valid 00Z Mon Apr 22 - 00Z Sat Apr 27
Calibrated with 1985-2010 Reforecast2 data.

120-240hr fcst from 00Z Wed Apr 17.
Valid 00Z Mon Apr 22 - 00Z Sat Apr 27
Calibrated with 1985-2010 Reforecast2 data.

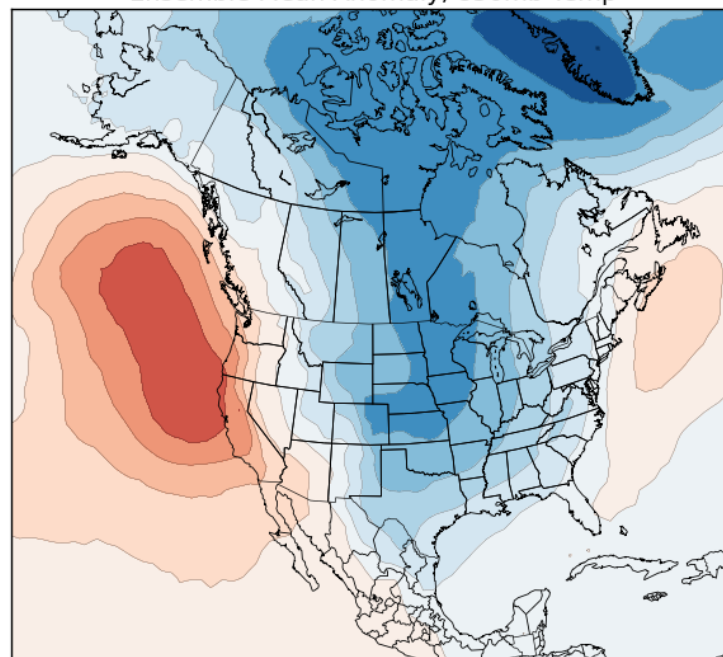
Probability of 850mb Temp in Upper & Lower Tercile



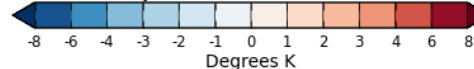
NOAA/ESRL Physical Sciences Division



Ensemble Mean Anomaly, 850mb Temp

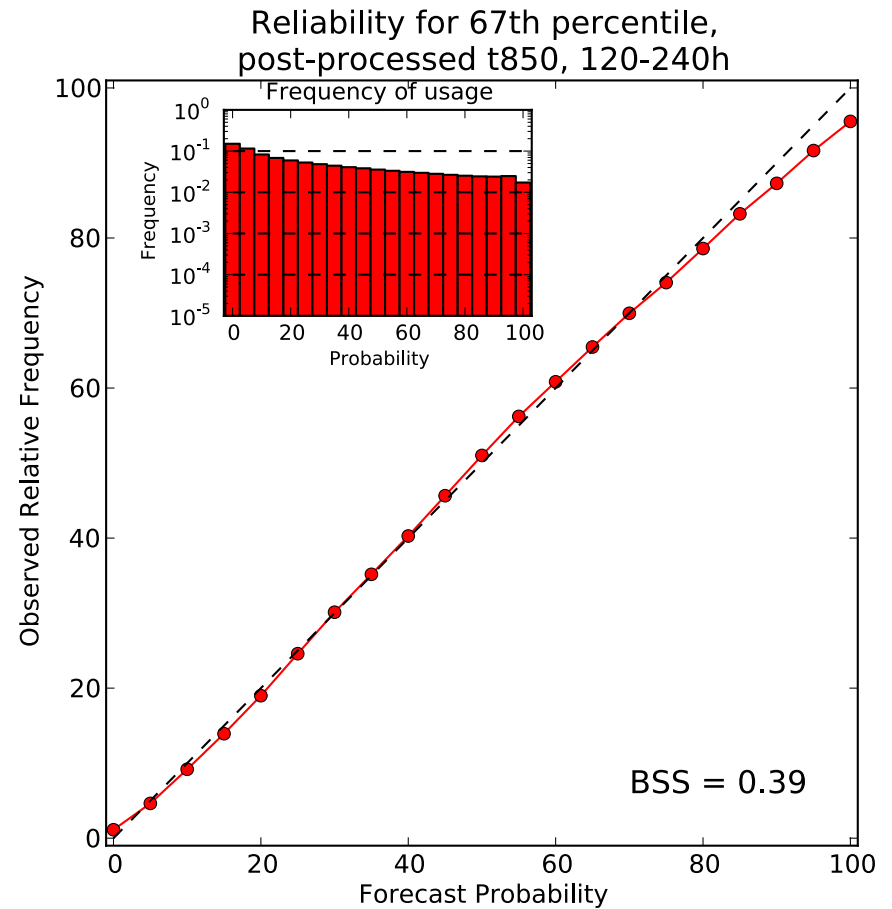
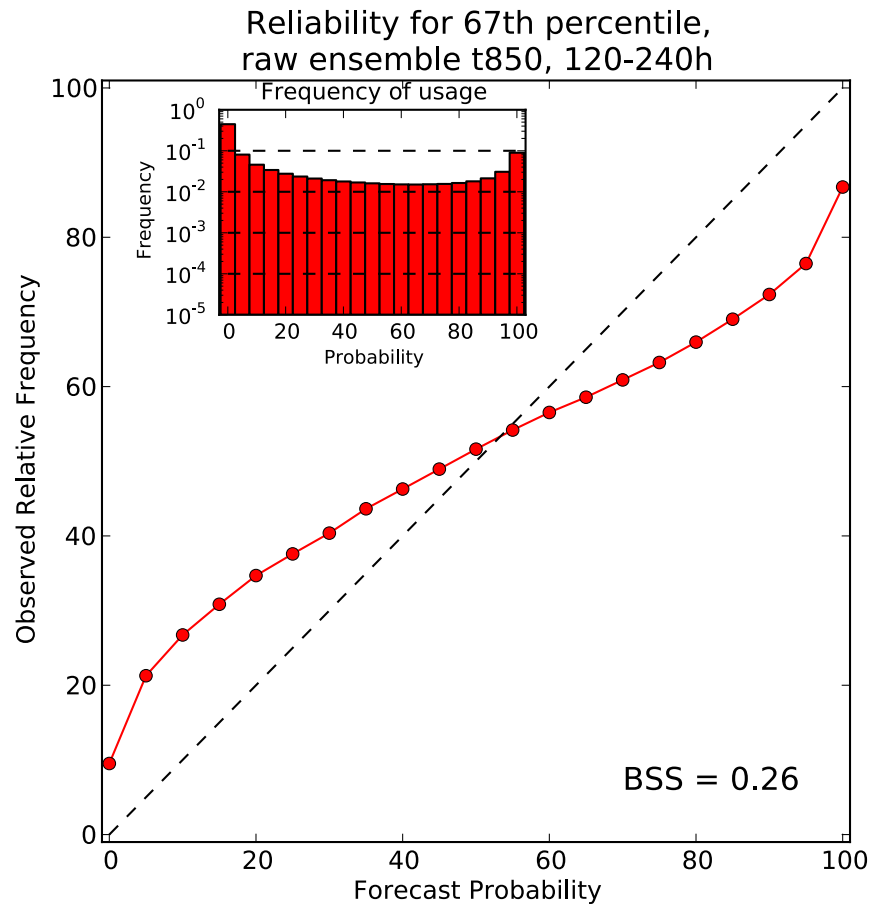


NOAA/ESRL Physical Sciences Division



<http://www.esrl.noaa.gov/psd/forecasts/reforecast2/medrange/index.html>

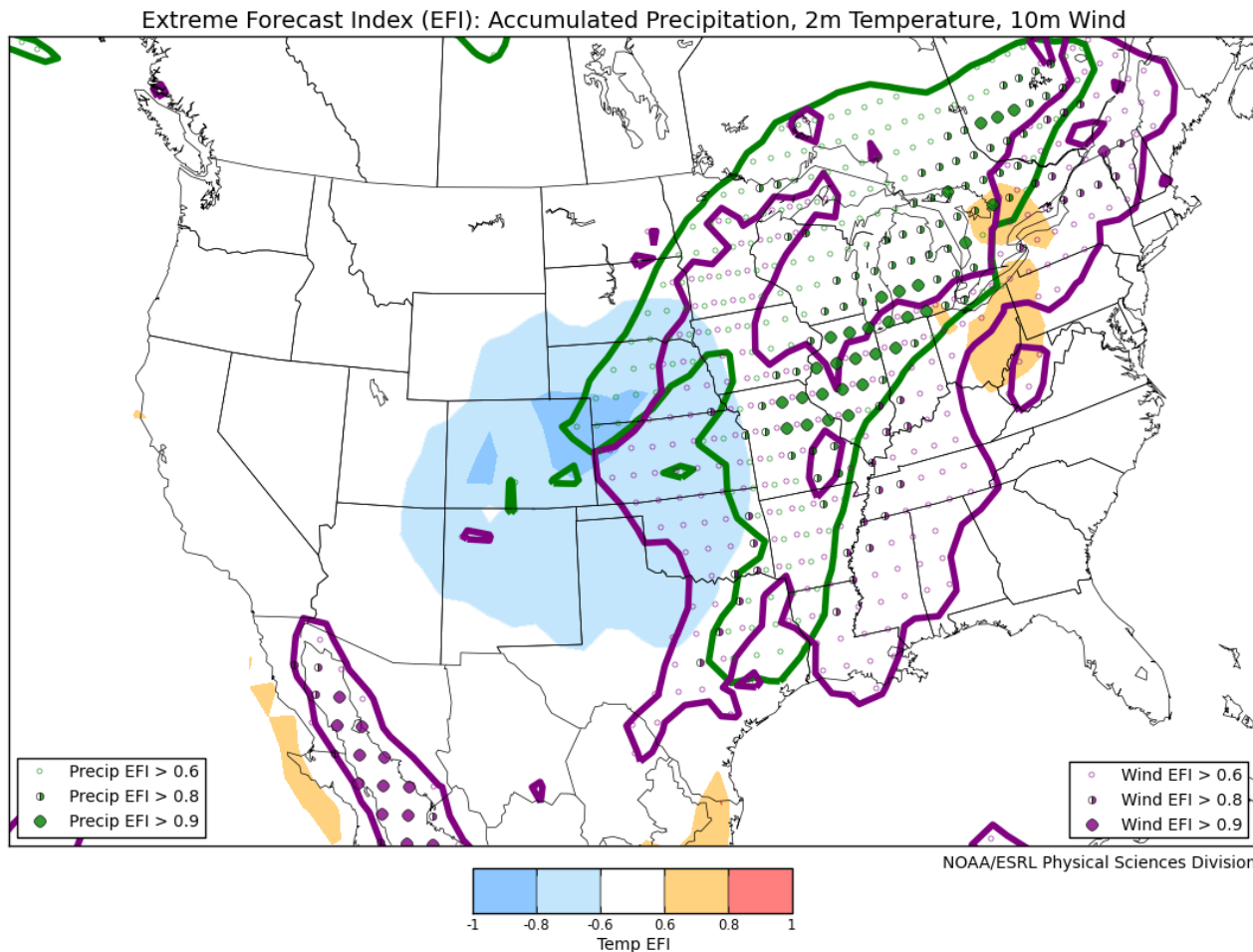
T850 reliability, upper tercile



Extreme forecast index (following ECMWF)

024-048hr fcst from 00Z Wed Apr 17. Valid 00Z Thu Apr 18 - 00Z Fri Apr 19

Based on 2nd-Generation GEFS Reforecast.

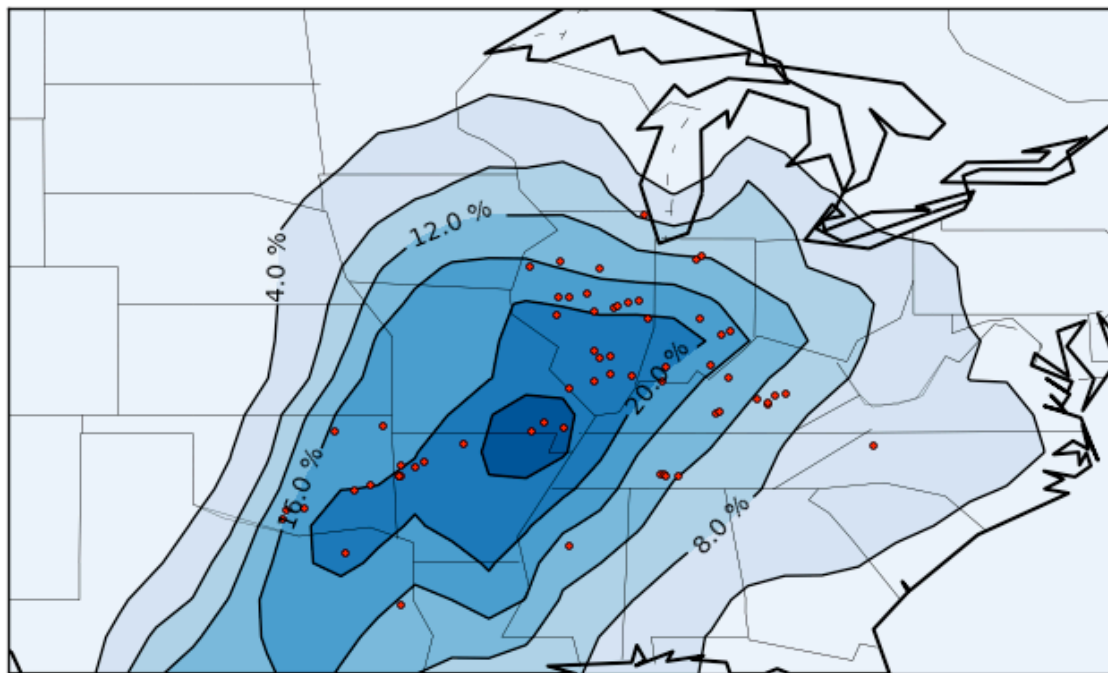


In the absence of observations or analyses for verification, the EFI can at least provide you with a heads-up of where the GEFS is unusual relative to its own model climatology for that time of the year.

(also available from <http://www.esrl.noaa.gov/psd/forecasts/reforecast2/analog/index.html>)

Research application: extended-range tornado forecasting

4/11/1996 Forecast, 204-hour through 276-hour leadtime
Using 3 PCs of 0-6 km Shear, log(CAPE) & Conv.Precip. as Predictors for Logistic Regression
Probability of tornado (>EF0) event



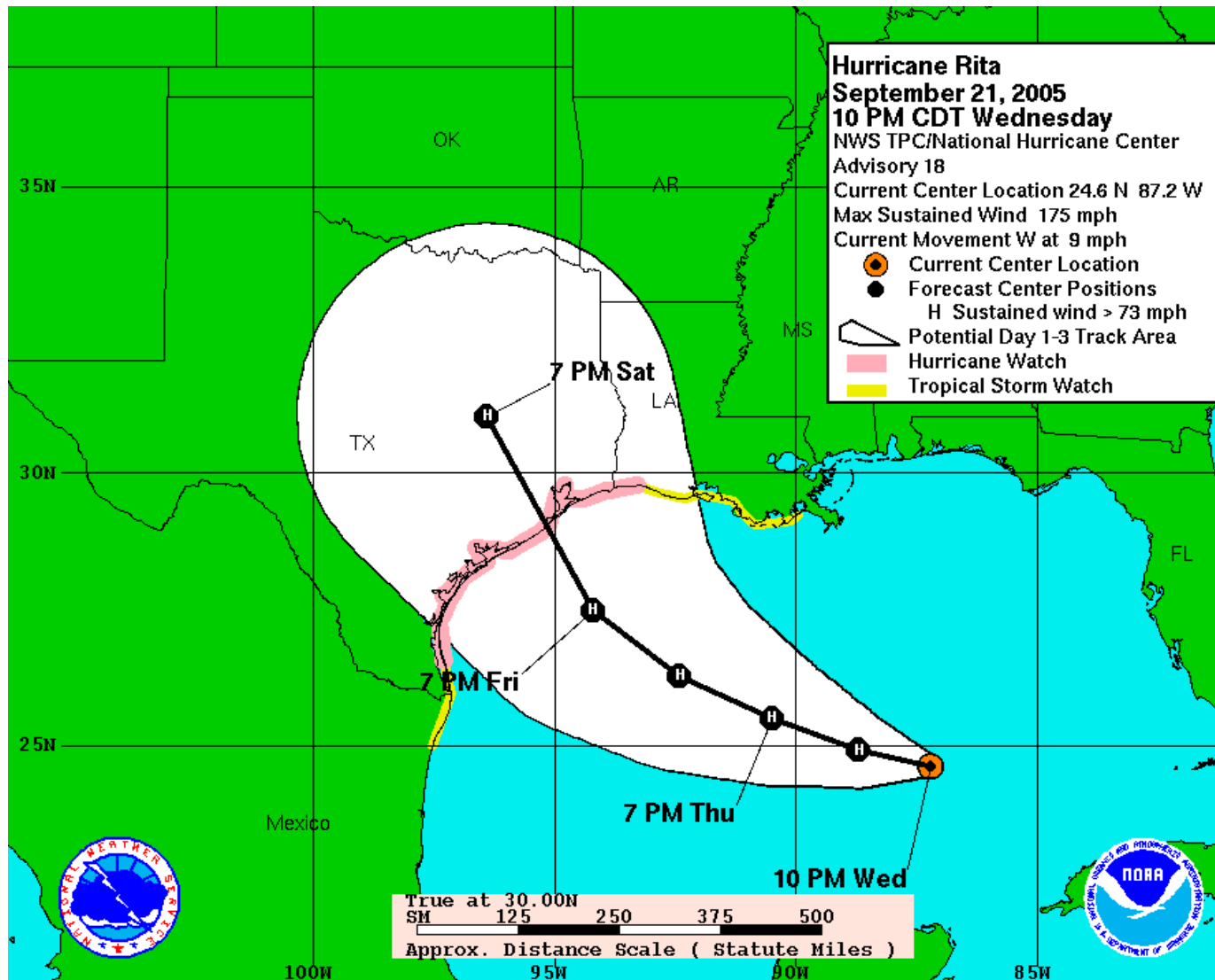
Francisco Alvarez,
St. Louis University,
is working with me
and others on using the
reforecasts to make
extended-range
predictions of
tornado probabilities.

Ph.D. work,
in progress.

Demo: Regional reforecast with WRF ARW v3.4 using global reforecast for initial, boundary conditions

- 2-way nested simulation 36-, 12- and 4-km with 36 vertical levels
 - 12- and 4-km moving nests
- Time step: 180, 60, and 20 s
- Initial and boundary condition: GFS reforecast ensemble member
- Tiedtke cumulus scheme on 36 and 12 km; explicit on 4 km
- YSU PBL scheme
- HYCOM ocean analysis
- WSM6 microphysics
- Noah land surface
- 2D Smagorinsky turbulence scheme
- Goddard shortwave radiation
- RRTM longwave radiation
- Second order diffusion
- Positive definite scalar advection
- Donelan wind-dependent drag formulation
- Garratt wind-dependent enthalpy surface fluxes

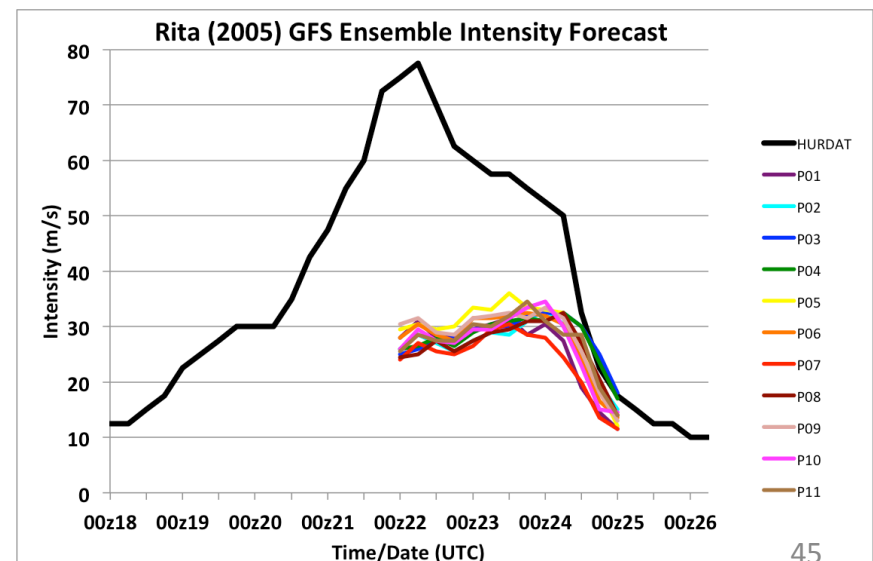
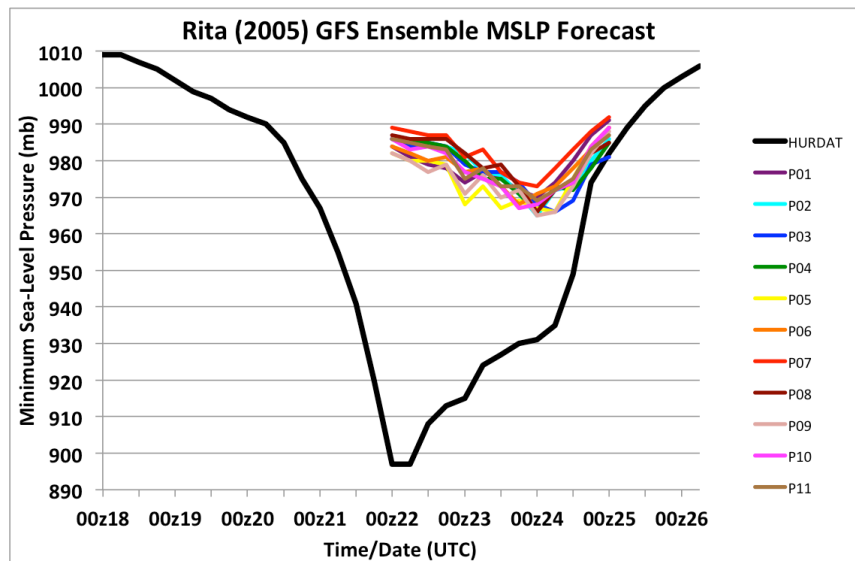
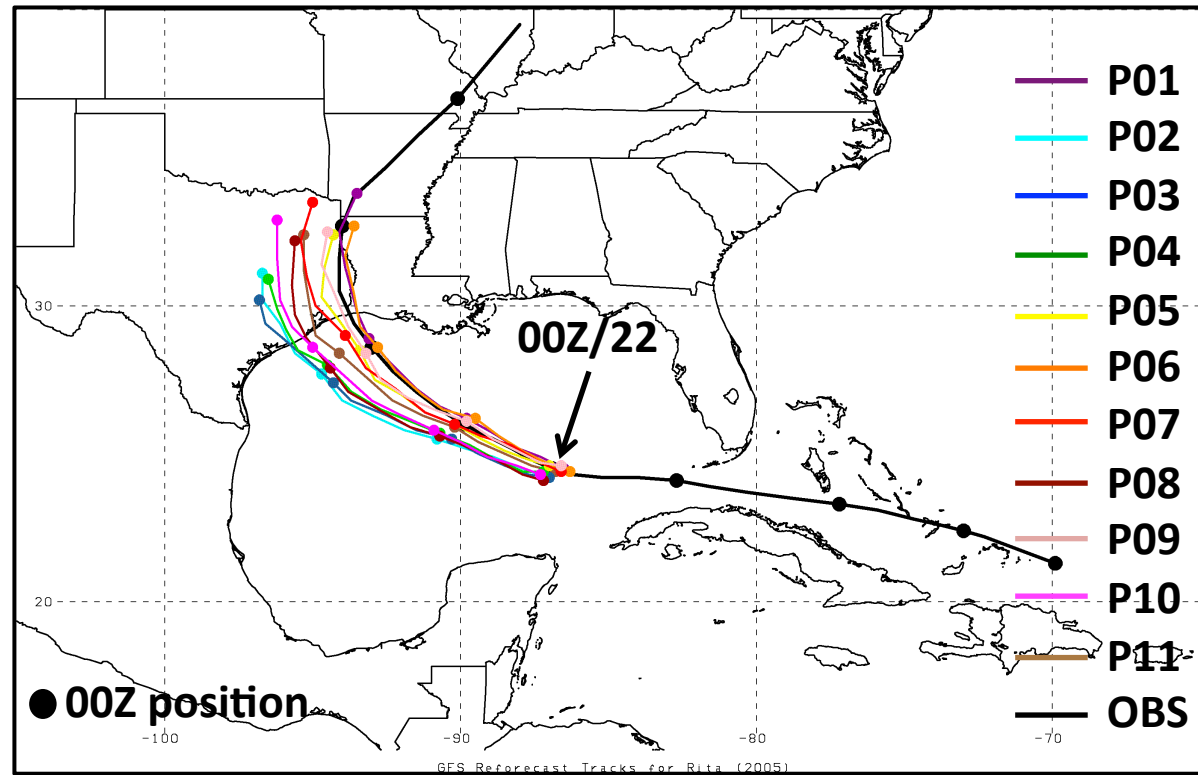
2005 Rita official forecast (Houston, TX evacuated)



TC Rita (2005)

GFS reforecast ensemble

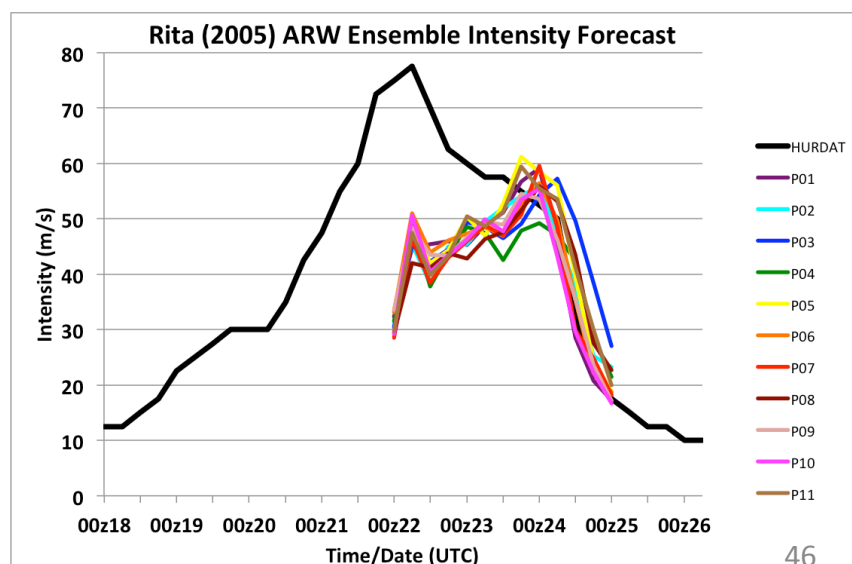
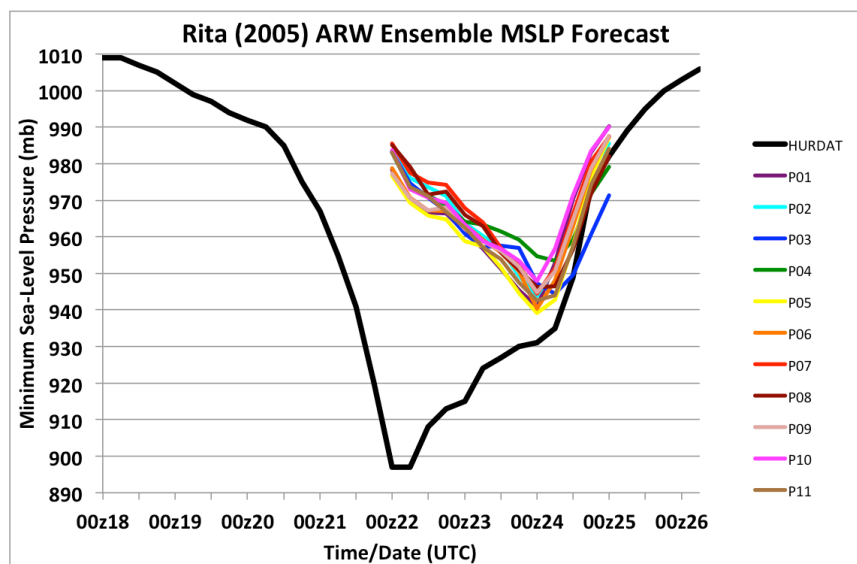
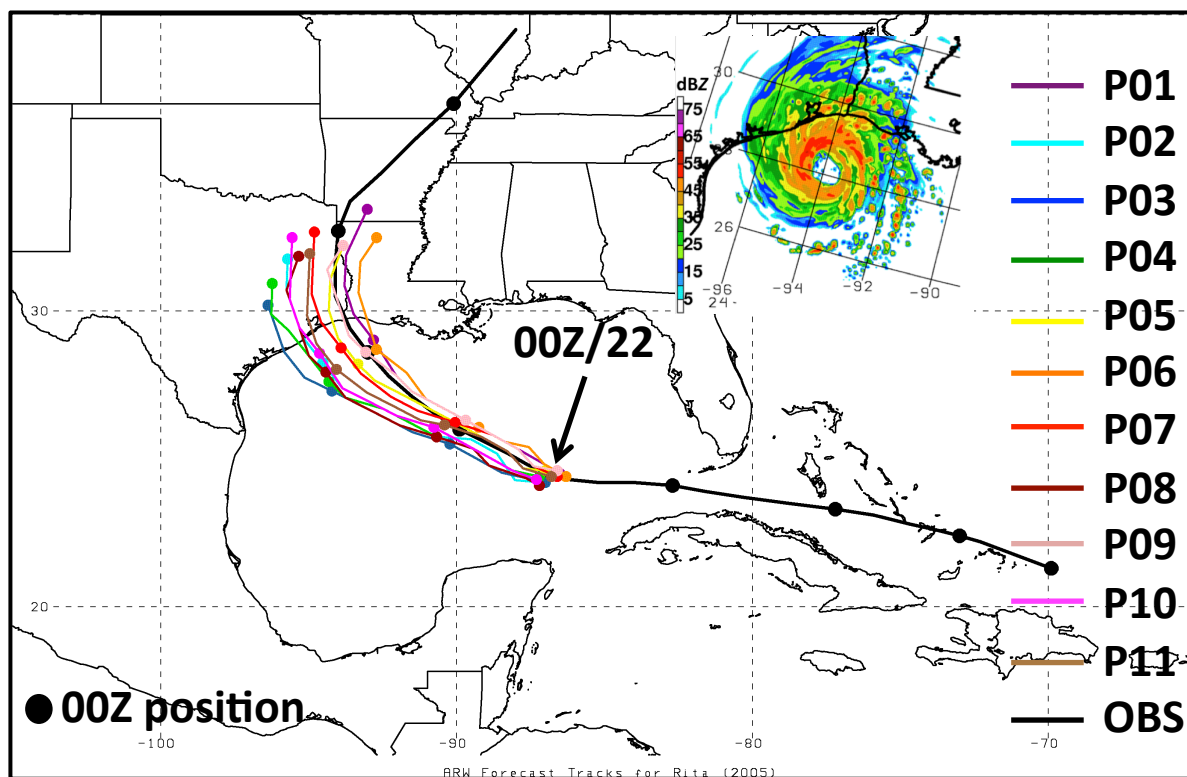
72-h forecast
initialized at 00Z 22 Sept



TC Rita (2005)

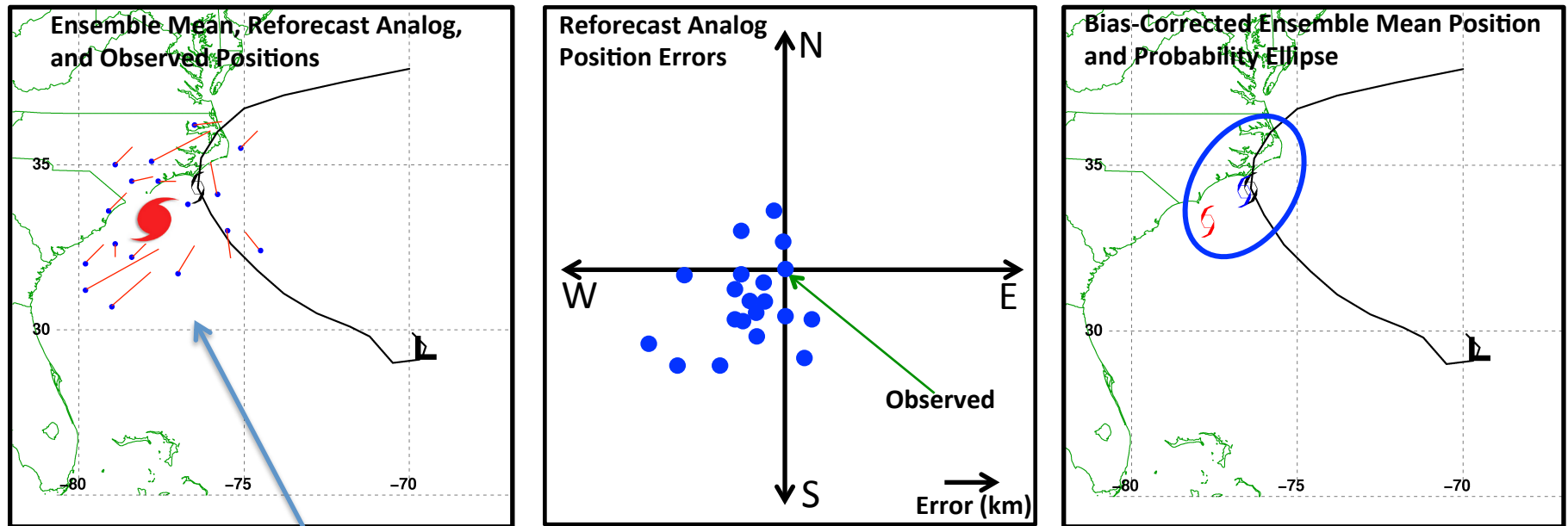
ARW ensemble with GFS
reforecast ensemble as
boundary and initial
conditions

72-h forecast
initialized at 00Z 22 Sept



A synthetic example of using reforecasts to make track error bias corrections

72-h Forecast Verifying 1200 UTC 9 September



Red 🌀: mean forecast position

Blue dot: forecast positions of +72-h forecast analogs

End of red tail ____: observed positions at +72 h

Conclusions

- Multi-decadal ensemble reforecast data set was created for current operational NCEP GEFS (circa 2012); useful for statistical calibration, regional reforecasting, understanding model biases, and much more.
- Reforecast and real-time forecasts data available now.
- Experimental forecast products available.
- We welcome your feedback on products, problems to esrl.psd.reforecast2@noaa.gov.
- If you find these reforecast products valuable, please communicate that to NCEP/EMC . They need to make decisions about whether & how to conduct reforecasts in the future on their operational system.
- An article on the data set and its applications is in press at BAMS, <http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-12-00014.1>